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Princeton '86.
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Dup. to Gen. Ref.

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HEAT AND LIGHT
FROM
MUNICIPAL AND OTHER WASTE

WRITTEN FOR
MUNICIPALITIES AND ENGINEERS

—BY—

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WITH FIFTY-SIX ILLUSTRATIONS

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HEAT AND LIGHT FROM MUNICIPAL AND OTHER WASTE

CHAPTER I.

INTRODUCTORY REMARKS.

The first consideration with all municipalities should be the safety and health of its citizens, and next, to secure for them at a reasonable cost those necessities controlled by public grants.

There is no more serious menace to the health of any community than its refuse, nor a greater necessity to the comfort and welfare of its citizens than plenty of heat and light at a moderate cost.

For the last twenty-five years this country, like all other countries, has been trying to meet these requirements of its citizens, by a better system of garbage disposal, and by more heat and light at less cost.

What has been the result of these efforts, I have attempted to set out in this work, without bias, and with but one purpose in view, that of calling the attention of our public officials and engineers to the success that has been made in this line in other countries, and how little success has been made by us.

Not only has the disposal of refuse not as yet been made sanitary in this country, but the enormous amount of public money which is annually spent for this work, can be seen by a comparison of the cost of refuse disposal per capita of American and foreign cities.

While the cost of refuse disposal rarely exceeds 1 cent per capita in any foreign city, it cost Philadelphia for the year of 1903, $514,875.00, or 38 cents per capita; Chicago $683,665, or 37 cents per capita; St. Louis $266,937, or 44 cents per capita; Boston $651,000, or $1.09 per capita; New York $78,144, or 2 cents per capita.

For 14 cities with a population above 300,000 the average cost per capita is 28 cents. The average of 23 cities between 100,000 and 300,000 population, is 23 cents per capita, while the average of 41 cities, between 50 and 100 thousand population is 26 cents per capita.

It will be seen from this that New York City alone compares favorably with foreign cities in cost of disposing of its refuse. This city is also the equal of any city in Europe in its system of collecting its waste.

The reason for this enormous discrepancy is that all refuse in foreign cities is incinerated, and the waste heat therefrom utilized for some public works, such as electric lighting, water works, sewerage pumping or mortar mills. With the single exception of New York City, which has recently installed an incinerating plant from which electric current is generated for the surrounding district, there is not another American city utilizing this waste heat in any form.

But, far more valuable than for any purpose that this heat has yet been utilized, is its future value to the modern central heating plants, permitting them to supply heat for large districts at a small cost.

The system of central heating is distinctly of Amerlcan origin, and the official data collected by me from those cities in which such systems have been installed, show the general satisfaction that they are giving to the public.

For the official data throughout this book, I am indebted to the public officials of the different cities, who I found not only willing to assist, in every way in their power, but anxious to secure any information which might be of service in securing for their cities a more satisfactory and economical solution of these problems.

JOSEPH G. BRANCH.

St. Louis, March, 1906.

CHAPTER II.

MUNICIPAL AND OTHER WASTE.

The two forms of waste treated in this work include only public waste in the form of refuse matter, and the private waste of exhaust steam from the power plants of citizens.

While both these forms of waste possess great value, the first, or the waste of the city's refuse, is by far the most important, for not only has it a much greater value, but is the source of constant danger to the health of every community.

Its value consists in its use as a fuel in incinerating furnaces, and the clinker therefrom, and the further valuable products derived by the reduction of its ingredients for grease and fertilizing purposes. Its danger lies in the noxious odors given off from the time that it becomes a refuse or waste until it is finally incinerated in high temperature furnaces, or reduced by proper reduction methods.

The term refuse includes all garbage, both from the kitchen or market, dead animals, miscellaneous refuse, street sweepings, and "night soil."

As the proper wording of contracts for disposal of refuse will depend not only upon what the term refuse includes, but upon its technical subdivisions, the follow-

ing definitions will be of service not only in drawing contracts for refuse disposal, but for city ordinances, which will legally cover the subject.

By the term "garbage" is meant all refuse of animal and vegetable matter which has been used as food for man, and all refuse animal and vegetable matter which was intended to be so used, and includes food condemned by the proper public officials.

The term "dead animals" means all dead animals or parts thereof, not intended to be used as food for man. The term "night soil" means the contents of box privies, except such as are established by contractors for temporary construction work, and human fecal matter deposited on streets, alleys, avenues, roads and open lots.

The term "miscellaneous refuse" means all refuse from places of residence and business except garbage, dead animals, night soil and ashes. Household rubbish does not include any material whatever in the nature of loom or sand, wall paper, lumber, bricks, stone, plaster, or other substance that may accumulate as the result of repairs to yards and dwellings, or other building operations. Manure is not included under any of the above classes of material.

The term "ashes" means ashes from coal and other fuels, including such mineral substances as fallen plastering, etc., as may accumulate in connection with the ordinary conduct of dwellings and places of business, but not such as may accumulate as the result of building operations.

PRODUCTS OF INCINERATION.

The only valuable product of incineration is the clinker, which is formed from the organic ingredients of the refuse burned.

The vapors and gases given off during incineration, are not only of no value whatever, but injurious to health unless completely consumed before being discharged into the atmosphere.

EXHAUST STEAM WASTE.

The discharge of exhaust steam from non-condensing engines and pumps, is the source of constant waste, as steam in this form retains a great number of heat units.

While there is no danger to health, or injury other than financial in its waste, if it cannot be utilized by the plant itself for heating purposes, or, used again as condensation, it should be sold to central heating plants at rates which will make it a source of mutual profit.

VALUE OF REFUSE AND EXHAUST STEAM.

The value of refuse and its products, and that of exhaust steam for our many modern requirements, will be gone fully into by me in the succeeding chapters, with the hope that it will call public attention to the rich commercial field hardly as yet entered by capital, and by so doing afford luxuries to many which are now enjoyed by but a few.

CHAPTER III.

INCINERATION AND REDUCTION.

Both the incinerating and reduction methods of refuse disposal have been on trial in this country for the last twenty years, and both methods to a large extent have proved failures. This is not due to any defects in the methods themselves, but alone due to the gross ignorance displayed in their application and operation. To attempt the incineration of refuse in a low temperature furnace is as absurd as to expect any method of garbage reduction to be a success, without requiring the proper sorting of all waste by the householder, and the hauling to the reduction works of only such refuse as is capable of sanitary and economical reduction.

But it must be admitted that irrespective of what method of reduction is adopted or how carefully the refuse may be sorted, that reduction works have always been, and will continue to be, a nuisance in any neighborhood in which they are located. The very character of the refuse which must be delivered to the works for reduction, being dead animals and kitchen and market garbage, must make it such, even with the most recent improved methods of destroying the noxious odors by passing them over live coals, or through high temperature furnaces.

But as such refuse has a greater value for the production of grease or a fertilizer, than it has as a fuel, it should

be sold, or properly reduced, and not destroyed by incineration. It is for this reason that at least one reduction plant should be operated by the city, but located without the city limits, or, in a locality where it cannot cause complaint. As only 23 per cent of the refuse can be so reduced, the remaining 77 per cent of the refuse should be incinerated at plants conveniently located in different sections of the city.

When dead animals and kitchen garbage is reduced by private companies, as is now done in most cities, it is not only a source of constant complaint, but of injury to the health of all the citizens within its locality.

Unless incinerating plants can be made *self-supporting*, companies operating reduction works will continue to offer to municipalities the seemingly more advantageous offer of reducing all the refuse for a term of years at no expense to the city, but such offers always carry a provision that the city must deliver all refuse to their reduction works.

Public officials deem it necessary to protect themselves by favoring any proposition which seemingly gives the city something for nothing. In fact, ordinances in most cities require that all contracts above a small amount shall be awarded to the lowest bidder, regardless of merit, or the ultimate cost or damages which may result. So long as such laws remain in force, just so long will American cities continue to be defrauded, and all public works be botched and retarded. While it is possible for propositions to be made in all fairness to reduce all refuse at a lower cost than can be offered by incinerating companies, the actual cost to the city can never be as small, for the reason that the *length of the haul* necessary to reach the reduction works can never be one-half as short as that

to the incinerating plant. As the cost of collection constitutes about 70 per cent of the total cost, the cost of disposal necessarily becomes secondary to the cost of collection. A reduction plant has always been and will always be a source of complaint in any neghborhood, and must therefore be removed to a locality distant from the city, thereby requiring a long haul to it. As a garbage wagon collects not more than 1½ tons of refuse on a trip, and as only one trip can probably be made each day from certain sections of the city to the reduction works, allowing $3.00 a day for a team, the great cost of collection, where reduction is employed, can be seen. While under the contract, the *disposal* would cost nothing, its *collection* would cost $2.00 per ton.

On the contrary, an incinerating plant, or plants, being located in convenient sections of the city, would permit the wagon to make six or eight trips per day, thereby reducing the cost of collection to not more than 35 cents per ton.

No reduction method will ever be devised which will enable a company or city to make a profit out of the refuse alone, for the analysis of the refuse of different cities shows that it cannot be of sufficient value to pay more than the expense of extracting those ingredients which have any value. Such companies must therefore rely upon a bonus paid by the city for their profit.

It is equally as true no incinerating plant can ever be made a financial success without utilizing the waste heat for some useful and profitable work.

There is hardly a civilized country on the globe, except America, which has not incinerating plants in successful operation, but they all utilize the waste heat for supplying light and power, and in this way succeed in disposing of

their refuse in both a sanitary and economical way.

Our country alone is just beginning to realize that there is nothing which affects the health of a community more than the sanitary disposal of its refuse, and that to do this, incinerating plants must be installed by competent engineers, and not by those whose only interest is a personal one. Incinerators of approved design must be installed by sanitary engineers who have made the subject not a study of a few months, but of many years.

The 187 incinerators in successful operation in Great Britain were built by high-class engineers, while not one of the hundred of failures in this country were designed or installed by an engineer of more than local reputation with the one notable exception of W. F. Morse, whose ability as a sanitary engineer is universally recognized.

The following report made by me contains the result of my investigation of this most important subject to all citizens alike:

REPORT.

Honorable Sanitary Committee, City Council, St. Louis.

GENTLEMEN:—I respectfully submit for your consideration the following official statistics collected by me of garbage and refuse disposal in the different cities of this country and Europe and Asia, together with a comparison of the reduction and incineration methods, both as to their sanitation and cost. It is admitted by all engineers, that England is at least fifty years in advance of this country both in the collection and the disposal of its garbage and refuse. It is further admitted that until recently both the reduction and incineration methods were in an experimental stage in this country. It was only after the reduction method had been tried and failed

in England, was incineration adopted there, and to-day there is not one municipal reduction plant in England, so far as I have been able to ascertain, while there are 143 municipal incinerating plants in successful operation, 120 of which plants supply, without extra cost, their different cities with electric lights, or power for their street railways, water works, or sewerage systems. In addition to the above number of incinerating plants in England alone, the three principal cities of Scotland, and the eight large cities of Ireland, dispose of their entire refuse by incineration. There is not a large city in Europe, South America, Africa, India, or Australia, which does not do likewise, and in every one of these different cities and countries the waste heat from the incinerating furnaces is utilized for municipal purposes of some description, usually for electric lighting, pumping or mortar mills. Owing to the prevalence of cholera in the far Eastern countries, the question of the collection and disposal of garbage was given for years their most careful consideration, and the incinerating method finally adopted. Both Calcutta and Bombay, India, employ incineration for the disposal of their garbage with perfect satisfaction, as well as Singapore, and even Shanghai, China, has an incinerator now under course of construction. The adoption of incineration for garbage disposal throughout the world can be seen from the appended list prepared by me.

It will be further seen from the official data collected by me, and which is also appended to this report, that the average cost per ton for disposal of the refuse in the English cities herein named is 26 cents, and in only six of these cities does the cost of disposal exceed 40 cents per ton. In Vienna, where the system of garbage reduction or utilization originated, it is not at present used,

and I can ascertain no city in Europe which is at present using the reduction method.

Official reports show conclusively that the reduction process has been a failure in every city in this country which has tried same, and especially so in Denver, St. Paul, Buffalo, Chicago, Milwaukee, Detroit, New Bedford, Reading, Pittsburg, Syracuse, Paterson and New Orleans.

There is but one municipal reduction plant in operation in this country, being the one at Cleveland, Ohio, and as to what success this city is having, it is sufficient to say that her sister city, Columbus, Ohio, is now having estimates prepared for an incinerating plant, after having tried the reduction method.

It has been repeatedly stated that the success of incineration in England and foreign countries was no criterion for American cities, as the composition of the refuse of this country is entirely different, it being more moist, and not having the same calorifc value. THIS IS INCORRECT. Official analysis shows but little difference where the WHOLE refuse is collected, which includes all ashes, street sweepings and combustible waste, as is done in England and in other foreign countries. The refuse of the average American cities is of the following composition:

	By Weight.	By Volume.
Garbage	13 per cent	18 per cent
Ashes	80 per cent	57 per cent
Rubbish	7 per cent	25 per cent
	100 per cent	100 per cent

Ordinary kitchen garbage consists approximately of:

	By Weight.
Animal and vegetable	20 per cent
Rubbish, cans, rags, etc	7 per cent
Grease	3 per cent
Water	70 per cent
	100 per cent

To cook the raw garbage and separate it into the four ingredients. i. e., rubbish, water, grease and fertilizer material, is the object of all reduction systems. The rubbish itself, being tin cans, rags, etc., has scarcely enough value to repay its separation, while the water has no value at all. These two ingredients compose 77 per cent of all garbage, and the expense of their separation constitutes the chief expense of all reduction plants. The remaining 23 per cent is of value, and should not be destroyed without some financial return, but it is equally as true that the high temperature necessary for the complete incineration of refuse should not be wasted up the stack, but utilized for power or heating purposes. This is apparent from repeated demonstrations that the waste heat from a 150-ton incinerator will develop 1,200 horsepower, the equivalent of 895 kilowatts of electric current, and smaller incinerators in like proportions. The loss from the failure to utilize this power would be greater than the loss from attempting to *reduce the entire city refuse.* The clinker which is left as a residuum forms 30 per cent of all the garbage and refuse incinerated, and this by-product has a ready sale and is especially valuable for street and paving purposes. The city of Memphis, Tenn.,

has twenty miles of her streets made from this clinker. It makes a high-grade mortar, and is otherwise extensively used.

Should this city collect all its refuse, including its ashes and combustible waste, as can be done by ordinance, there is not the slightest doubt but incineration will be a complete success, the same as in all the above-named cities, and at a cost not exceeding 15 cents per ton for its disposal, provided the waste heat is utilized. But, to attempt incineration without making use of the ashes, which contain at least 20 per cent of coal, and consequently of a high calorific value, and the further use of all combustible waste, consisting of street sweepings, boxes, etc., will render the cost excessive, and, indeed, prohibitive, if the waste heat is not utilized. The per cent of coal in the ashes in this country is much greater than in foreign countries, making such waste more than ordinarily valuable.

It has been clearly shown that where incineration failed in this country, that it was due to improperly constructed furnaces, and attempting to burn the wet garbage alone, without the aid of the combustible refuse. This is as great a mistake as to employ the reduction method, without requiring a sorting of all refuse by the householder. As only 23 per cent of the refuse of a city is capable of reduction, it leaves the remaining 77 per cent to be disposed of by incineration. Whether the city can best dispose of this 23 per cent by selling the same outright, as it is partially now doing, or by reducing it at its own municipal plant, or by incinerating it with the other refuse, is a question for the decision of your Honorable Committee. Should the incinerating method be adopted, either in part or for the entire refuse of the city, no

incinerator should be accepted, in my opinion, which does not provide for the utilization of the waste heat under boilers, should, at any time, it be desired to use same, and I base my opinion upon the fact that of the 184 incinerating plants in successful operation, that there is not one which DOES NOT UTILIZE THE WASTE HEAT in this manner. I know of no method other than the use of boilers, separate and distinct from the incinerator, which is either practical, or will develop more power than is merely necessary for the operation of the incinerator itself. For such power purposes the use of water-jacketed furnaces is impractical, while the use of an auxiliary furnace, as a stench destroyer, renders the use of boilers for such purposes impossible, and is also antiquated. I know of only three plants, out of the above number of 184 plants, employing such a stench destroyer, it being entirely unnecessary in a properly built furnace.

As the cost of collecting the garbage and refuse constitutes 70 per cent of the total cost, there should be at least four incinerators located in different sections of the city, or three incinerators and one reduction plant for the animal and grease matter alone, thereby reducing as far as possible the length of the haul. At present some of the wagons are able to make only two trips a day, and several only one trip. As the city at present is paying about $40,000 annually for its lighting, in addition to the expense of its own municipal plants, I would advise the saving of this by having built properly constructed furnaces, and utilizing the waste heat therefrom for boiler power.

CHAPTER IV.

BRITISH AND FOREIGN DESTRUCTORS AND INCINERATORS.

As it was in England that the incinerator was first made a complete success, it is to the English incinerator or destructor, as it is there called, that we should look for information and reasons for our numerous failures.

The first successful English incinerator was erected in 1876, at Manchester, by Mr. Alfred Fryer, and during the thirty years intervening, this incinerator has been in daily use and giving such perfect satisfaction, that there is hardly a town or city in England, Scotland or Ireland that has not now in successful operation, or in course of erection, some type of an incinerator patterned after this one.

In 1886, only ten years after the installation of the Fryer incinerator, the Engle incinerator was installed in this country, and yet today incineration here is not as far advanced as it was thirty years ago in England. We are still working with low temperature furnaces, using natural draft and operating the plant with cheap labor, all of which was discarded as improper by English engineers at least fifteen years ago. The success of incineration in England is due largely to the high class of the

engineers who have devoted their time and talents to what has long been recognized the world over as a problem requiring the highest class of engineering skill for its solution.

The designor of the modern incinerating plant must not only be a competent sanitary and mechanical engineer, but an electric and steam engineer as well.

The trouble with us has been, not that we have no competent engineers, but that they have not been called upon by our cities for this class of work.

Following the successful test of the Fryer incinerator at Manchester, other successful types were rapidly produced, and at present there are a dozen high-class companies installing and remodeling incinerators throughout the British islands.

Among the leading types of British incinerators which are now in successful operation, are the Beaman & Deas, the Fryer, the Heenan, the Horsfall, the Meldrum and the Warner.

The following list of English and foreign cities employing incineration for the disposal of all refuse, with the purposes for which the waste heat therefrom is utilized, was compiled by me from the official data given in that most thorough English work of W. F. Goodrich on "Refuse Disposal and Power Production."

MUNICIPAL INCINERATORS
for
GARBAGE DISPOSAL AND POWER PRODUCTION.

ENGLAND.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Accrington	43,122	60	31 cts.	Electric Lighting.
Aldershot	14,248	11	25 "	Sewerage Pumping.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Ashton-under-Lyne..	43,890	30	23 cts.	Electric Traction.
Aston	77,310	75	22 "	Two Installations. Mortar Mills and Clinker Crusher and Lighting.
Bangor	11,770	9½	32 "	Electric Lighting.
Barry	27,000	25	28 "	Mortar Mills.
Bath	49,821	45	27 "	Mortar Mills and Crusher.
Beckenham	26,000	24	42 "	Electric Lighting.
Batley	30,321	15	30 "	Electric Lighting.
Birkenhead	111,102	180	21 "	Two Installations. Mortar Mills. 90 tons each.
Birmingham	522,204	400	19 "	Four Installations. Mortar Mills, Work Shop, Machinery and Electric Lighting.
Blackburn	129,216	130	21 "	Four Installations. (1) 40-ton Mortar Mills; (2) 15-ton Work Shop; (3) 30-ton Gas Works; (4) 45-ton Water Pump'g
Blackpool	50,330	...	30½ "	Four Installations. Electric Lighting.
Bolton	171,082	...	20 "	Four Installations. Mortar Mills and Sewerage Pumping.
Bootle	58,566	...	22½ "	Mortar Mills and Crusher.
Bournemouth	47,000	30	18 "	No power available.
Bradford	279,767	240	18 "	Four Installations. Electric Lighting and Works Purposes
Brentford	15,613	14	.. "	Sewerage Pumping and Lighting.

City.	Population.	Daily Tons.	Cost per ton.	Power Purposes.
Brighton	124,539	72	31 cts.	Mortar Mills.
Bristol	328,842	108	22½ "	Mortar Mills.
Burnley	97,044	70	.. "	Two Installations. Electric Lighting, Fan Engine only.
Burstem	38,766	25	29 "	Two Installations.
Burton-onTrent	50,386	45	32 "	Works Purposes and Water Pumping.
Bury	58,028	...	23 "	Two Installations.
Buxton	10,181	12	22 "	Sewerage Pumping.
Cambridge	38,398	35	27 "	No power available.
Canterbury	24,868	20	26 "	Sewerage Pumping.
Cheltenham	49,439	40	15 "	Electric Lighting.
Chesterfield	27,185	25	15 "	Mortar Mills.
Cleckheaton	15,250	12	..	Sewerage Pumping.
Colne	23,000	18	21 "	Electric Traction.
Croydon	137,000	...	..	Electric Lighting. Three Incinerators in course of construction.
Dartford	18,643	20	..	Electric Lighting and Pumping.
Darwen	40,000	35	24 "	Electric Traction and Lighting.
Derby	113,863	...	..	Two Installations.
Dewsbury	28,060	28	28 "	Mortar Mills.
Ealing	33,040	...	..	79-H.P. Sewerage Pumping and Sludge
Eastbourne	43,337	35	..	Natural draft, 3 B & W boilers.
Eastham	100,000	...	..	Sewerage Pump'g. Experimental Power Plant.
Eccles	34,369	30	..	Sewerage pumping and Clinker Crushers
Elland	10,412	10	..	Electric Lighting .
Epson	10,915	10	..	Just completed.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Fleetwood	12,082	12	.. cts.	In course of erection Electric Lighting. 200-h.p. 600 amp. hrs.
Folkstone	30,690	...	..	In course of erection
Garston, (City of Liverpool).	18,710	25	..	Electric Traction. 140-h.p. 400 amp. hrs.
Glancester	47,955	25	20 "	Electric Lighting.
Gosport	28,887	...	..	In course of erection
Gorton	28,000	...	..	In course of erection
Grantham	17,598	...	..	No data.
Grays	15,834	8	20 "	Electric Lighting.
Grovesend	27,196	25	..	Electric Lighting.
Great Grinsley.....	63,318	30	..	Mortar Mills and Electric Lighting.
Great Yarmouth....	51,250	78	..	Natural Draft.
Handsworth	52,921	50	21 "	Fans only.
Henley	61,599	60	..	Electric Works.
Hartle Pool.........	22,737	20	..	Fan Engine only.
Hastings	65,528	36	38 "	Pumping Salt Water
Heckmondwike	11,000	...	24 "	Two Installations. Works Purposes only
Hereford	21,328	10	18 "	Sewerage Pumping
Heywood	25,461	25	..	Sewerage Pumping
Holyhead	10,079	10	..	Electric Light, not complete.
Hornsbury	6,736	6	..	Sewerage Pumping Not complete.
Hornsey	77,938	75	18 "	Mortar Mills, Clinker Crusher.
Huddersfield	95,047	70	..	Two Installations. (1) 50-ton Works Purposes. (2) 20-ton Sewerage Pump.
Hall	240,739	135	30 "	Two Installations. (1) 45-ton Works Purposes. (2) 20-ton Lighting.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Hunstanton	1,893	3⅓	24 cts.	Water Pumping.
(Smallest known power installation)				Produces sufficient steam to operate modern pumping plt.
Hyde	32,766	30	28 "	Sewerage Pumping.
Ipswick	66,630	40	..	Electric Lighting.
Kettering	300,000	30	..	Electric Lighting.
Kingston	34,375	30	..	Work Purposes only. Not yet in operation.
Lancaster	40,329	30	32 "	Electric Traction.
Leamington	26,888	25	..	Sewerage Pumping.
Leeds	428,968	...	21 "	Four Installations. Works Purposes.
Leecester	211,581	180	17 "	Four Installations. Works Purposes. Mortar Mills.
Levensulme	11,435	...	..	Now in course of Construction.
Liverpool	710,737	...	..	Four Installations. (1) Mortar Mills and Works Purposes. (2) Works Purposes. (3) Works Purposes. (4) Elec. Lighting.
Liversodge	13,980	13	..	Works Purposes.
Llandudno	9,310	15	31 "	Electric Lighting.
Longton	35,815	70	44 "	Works Purposes. Two Installations.
Lowesroft	29,850	28	23 "	Mortar Mills.
Loughborough	21,508	40	28 "	Sewerage Pumping. Two Installations.
Luytham	7,185	10	16 "	Sewerage Pumping.
Manchester	543,872	...	..	Mortar Mills and Works Purposes.
Mansfield	21,445	21	..	Electric Lighting.
Mexborough	10,430	20	22 "	Electric Lighting.

City.	Population.	Daily Tons.	Cost per ton.	Power Purposes.
Morecambe	11,798	11	25 cts.	Mortar Mills and Electric Lighting.
Moss Side	26,677	26	16 "	Mortar Mills, Works Purposes.
Nelson	32,816	30	24 "	Electric Traction.
Newcastle	215,328	150	17 "	Two Installations. No power available.
Newmarket	10,686	9	22 "	Sewerage Pumping.
Northampton	87,021	80	..	Electric Traction.
Nottingham	239,753	...	..	Three Installations Electricity.
Nuniation	15,246	15	20 "	Sewerage Pumping.
Oldham	137,238	120	57 "	(1) Works Purposes; (2) Clinker Crusher, Mortar Mills. (3) Public Baths and Wash-houses.
Padiham	12,005	12	44 "	Works, Power and Electric Purposes.
Pantypridd	32,319	...	..	Power and Elec. Purposes.
Plymouth	107,509	100	..	Three Installations (1), (2), no data.
			25 "	(3) Elec. Traction.
Preston	112,989	108	23 "	Three Installations.
Radcliff	25,368	26	20 "	Sewerage Pumping.
Ramsgate	27,686	26	..	Works Purposes.
Rawtenstall	31,053	28	..	Works Purposes.
Rhyl	8,473	16	32 "	Electric Lighting.
Rochdale	83,114	40	15 "	Works Purposes.
Rhonda	117,000	16	62 "	No power available.
Rotherham	54,348	40	25 "	Works Purposes.
Royton	14,881	20	19 "	Works Purposes.
St. Annes-on-Sea....	6,807	6	32 "	Works Lighting.
St. Helens..........	87,385	32	28 "	Electric Traction.
St. Heliers.........	......	15	..	Forced Draught.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Salford	220,957	...	.. cts.	Five Installations. No. data 1, 2, 3, & 4. (5) Works Purposes.
Salisbury	17,117	16	30 "	Sewerage Pumping.
Shierness	14,492	10	24 "	Water Pumping.
Sheffield	410,991	200	46 "	Two Installations. Works Purposes.
Shipley	26,000	25	21 "	Electric Light, Sewerage.
Smethwick	54,537	55	..	Not yet decided.
Southampton	107,833	70	59 "	Two Installations. Sewerage Pumping.
Southport	48,083	40	28 "	Gas Works.
Southwold	2,800	2	..	No power available.
Stafford	20,894	20	32 "	Sewerage Pumping.
Stockton on-Tees	51,478	20	18 "	Mortar Mills.
Stoke-onTrent	30,800	30	..	Electric Lighting.
Stowbridge	16,302	...	..	No data.
Stretford	30,436	18	32 "	Works Purposes.
Sudbury	7,109	5	..	Sewerage Purposes.
Swansea	94,615	...	..	No data.
Taunton	21,078	20	..	Sewerage Pumping.
Taequay	33,625	25	19 "	Works Purposes.
Tottenham	106,800	80	..	Electric Lighting.
Wakefield	51,544	40	..	Two Installations. Electric Lighting, Sewerage Pumping.
Wallasey	55,000	40	22 "	No power available.
Walker-onTyne	13,335	30	14 "	Works Purposes.
Watford	29,023	40	..	Sewerage Pumping.
Warrington	64,242	64	55 "	Two Installations. (1) Elec. Lighting. (2) Sanitary Manure Works.
Wellingborough	18,142	12	..	Electricity.
Wess Bridgeford	7,018	7	..	Sewerage Pumping.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
West Hartlepool....	62,627	60	21 cts.	Electric Light and Works Purposes. Two Installations.
Weymouth	19,831	16	..	Sewerage Pumping.
Wimbledon	45,000	54	40 "	Sewerage Pumping.
Winchester	20,919	19	20 "	No data.
Withington	36,032	36	16 "	Sewerage Pumping.
Wolverhampton.....	94,187	...	..	Works Purposes.
Worthing	22,617	...	..	No data.
Wrexham	14,966	35	..	Electric Lighting.
York	77,914	...	..	Works Purposes.

SCOTLAND AND IRELAND.

Ayr	28,697	30	..	Electric Lighting.
Edinburgh	316,793	60	59 "	Forced Draught.
Glasgow	781,000	400	..	Six Installations. No data 1, 2, 3. (4) Works Purposes. (5) Forced Draught. (6) Works Purposes.
Gourock	5,261	5	20 "	Fan Engine.
Govan	82,174	80	24 "	Works Purposes.
Paisley	79,363	62	19 "	Mortar Mills, Two Forced Draught.
Partick	54,298	42	39 "	Electric Lighting.
Port Glasgow.......	16,857	25	..	Not yet determined.
Belfast	348,965	100	18 "	Fan Engine.
Dublin	265,000	25	19 "	Mortar Mill, 12-h.p.
Pembroke	25,524	12	23 "	Electric Lighting.

CANADA.

Montreal	267,516	...	..	No data.

SOUTH AMERICA.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Bahia	....	...	.. cts.	No data.
Buenos Ayres (Argentine)	....	...	..	No data.
Georgetown (British Guinea)	....	...	..	No data.
Manaos (State of Amazonas)	....	...	..	No data.
Para (Brazil)	....	...	..	No data.
Pernambucco (Brazil)	....	26	..	Mortar Mills.
Peru	....	...	..	No data.

BELGIUM.

Brussels	....	...	..	Work Purposes.

DENMARK.

Copenhagen	....	...	..	Lighting Purposes.
Gibraltar	....	...	15	"

GERMANY.

Berlin	....	...	..	No data.
Hamburg	....	30	..	Forced Draught.
Monaco	....	30	..	Forced Draught.

FRANCE.

Paris	....	...	..	No data.

SWITZERLAND.

Zurich	....	...	..	Electric Power.

The incinerating plant recently installed in this city contains two boilers supplying steam at high pressure. Forced draft is used. The refuse contains from 30 to 40 per cent incombustibles.

SOUTH AFRICA.

City.	Population	Daily Tons.	Cost per ton.	Power Purposes.
Durban (Natal)	....	...	.. cts.	No data.
Bloemfontein (Orange River Colony)	....	...	..	No data.
East London (Natal)	......	...	..	No data.
Johannesburg (Transvaal)	....	120	..	No data.

AUSTRALIA.

Melbourne (South)	....	...	..	No data.
Melbourne (Victoria)	....	...	..	No data.
Toowoomba (Queensland)	....	...	....	No data.
Sydney (New South Wales)	....	...	..	No data.
Ammandale & Leichard (Sidney) (New South Wales)	...	...	..	No data.

NEW ZEALAND.

Christchurch	....	...	..	Electric Lighting.
Wellington	....	...	..	No data.

INDIA.

Calcutta	....	...	..	No data.
Bombay	....	...	..	No data.
Karachi	......	...	..	No data.
Madras	....	...	..	No data.

THE FAR EAST.

Singapore (Straits Settlements.)	....	...	..	No data.

CHINA.

Shanghai	....	...	....	No data.

DETAILS OF I. H. P. OBTAINED FROM ENGLISH DESTRUCTORS.

Compiled by B. Ball, Esq., A. M. I. C. E., Borough Engineer, Nelson. From Goodrich's "Disposal of Towns' Refuse."

Name of Town.	Number Cells.	Makers.	Quantity of Refuse Burnt per cell per day in Tons.	Total Quantity burnt per day in Tons.	Number and Type of Boilers.	Total I. H. P. obtained.	I H. P. per ton burnt in 24 hrs.
Bath	8	Warner's	5	40	1 Multitubular, 14 ft. by 8 ft.	Drives 20 H. P. Engine	.5
Batley	6	Fryer's	3½	21		" 30 " "	1.43
Battersea	12	Do.	6	72	1 60 H.P. Multitubular		
Blackburn	8	Do.	6	48		" 45 " "	.93
Hammerton St., Bradford	12	Horsfall's	9.13	54	2 Multitubular, 11 ft. by 8 ft.	" 185 " "	3.42
Bury	4	Fryer's	6.5	26		" 12 " "	.46
Dewsbury	2	Beaman & Deas.	15	30	1 Babcock	" 80 " "	2.6
Ealing	7	Fryer's	4.5	31		" 35 " "	1.12
Hereford	2	Meldrum's	19	38	2 Galloway, 22 ft. by 6 ft. 6 in.	" 236 " "	6.21
Meanwood Rd., Leeds	8	Horsfall's	7	56	2 Babcock	" 265 " "	4.73
Needham St., Leicester	6	Fryer's with Biddles bars.	9	54	1 50 H.P. Multitubular.		
Leyton	8	Beaman & Deas.	16.2	65	2 Babcock	" 90 " "	1.38
Oldham	10	Horsfall's	8	80	2 Lancashire, 30 ft. by 8 ft.	" 200 " "	2.5
Rochdale	2	Meldrum's	23	46	Do.	" 350 " "	7.6
Southampton	6	Fryer's	10	60	Multitubular	" 40 " "	.6
Warrington	4	Beaman's	15	60	Babcock	Drives about 300 H.P. **Engine**	**5.0**

DETAILS OF EVAPORATIVE TESTS IN CONNECTION WITH ENGLISH DESTRUCTORS.

Compiled by the Surveyor of Nelson, Lancashire. From Goodrich's "Disposal of Towns' Refuse."

TOWN.	Type of Furnace.	Duration of Test.	Quality of refuse.	Total weight of refuse burned.	Weight of refuse burned per hour.	Total weight of water evaporated.	Water evaporated per hour	Water evaporated per lb of refuse burned.	Average steam pressure.	Temperature of feed water.
		hrs.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
Oldham........	Horsfall	24	Unscreened	71,320	2,972	78,900	3,287	1.16	128	57°F.
Do.	Do.	24	Do.	106,980	4,457	78,100	3,254	.73	128	57°F.
Bradford.......	Do.	..	Do.	721,280	5,115	523,000	3,709	.725	60	50°F.
Huddersfield...	Do.	24	2 refuse to 1 of sludge..	70,560	2,940	83,040	3,460	1.17	61 to 71	Cold
Rochdale.......	Meldrum	6	Unscreened.....	25,536	4,256	42,072	7,012	1.64	113	53°F.
Do.	Do.	6½	Do.	30,800	4,738	42,900	6,600	1.39	113	52°F.
Do.	Do.	6½	Do.	32,142	4,945	47,400	7,290	1.47	113	52°F.
Hereford.......	Do.	10	Do.	19,768	1,976	26,254	2,625	1.32	70	48°F.
Do.	Do.	10¼	Do.	19,012	1,855	25,570	2,494	1.34	70.2	48°F.
Do.	Do.	10	Do.	19,712	1,971	29,800	2,980	1.51	70.92	48°F
Warrington....	Beaman & Deas..	6	Radcliffe refuse.	21,700	3,617	22,000	3,666	1.01	45	141.5°F.
Do.	Do. ..	5¾	1 refuse to 1 sludge........	25,088	4,363	32,000	5,565	1.27	..	65°F.
Do.	Do. ..	24	Unscreened	53,544	2,231	61,344	2,556	1.14	68	104°F.
Do.	Do. ..	5 5-6	Do.	18,509	3,173	27,791	4,766	1.5	53	135°F.
Leyton.........	Do. ..	12	2 refuse to 1 sludge	74,956	6,246	31,920	2,660	.426	105	63°F.

CHAPTER V.

AMERICAN INCINERATORS.

During the last twenty years there has been installed in American cities about twenty different types of incinerators, and it must be admitted that not one has proved a complete success.

One of the first types of incinerators installed was the Engle, which was installed at Des Moines, Iowa, as an experiment in 1886, and subsequently installed in some dozen or more American cities with varying success.

During the succeeding twenty years, the following are some of the types installed, with their principal installation, viz.: the

Brown incinerator at Wilmington, Del.
Brownlee incinerator at Terre Haute, Ind.
Burns incinerator at Brooklyn, N. Y.
Anderson incinerator at Chicago, Ill.
Dixon incinerator at Atlanta, Ga.
McKey incinerator at Yonkers, N. J.
McGiehan incinerator at Syracuse, N. Y.
Reder incinerator at Pittsburg, Pa.
Smith-Siemens incinerator at Atlantic City, N. J.
Smith-Vivarttas incinerator at Scranton, Pa.

The failure of these and other types was due to their improperly constructed furnaces and the lack of sufficient draft, rendering it impossible to maintain the necessary high temperature for the complete incineration of refuse

In none of these furnaces could a temperature much above 1000 degrees F. be obtained, while the complete incineration of refuse requires a constant temperature of 2000 degrees, owing to mixed refuse containing from 70 to 80 per cent moisture.

The construction of all these incinerators was imperfect in requiring the wet refuse to be charged direct into the furnaces without first drying same, either upon a drying hearth, or in an intermediary furnace. The result was that the heated fire-brick were quickly cooled off by each successive charge, thus keeping the temperature of the furnace too low for perfect combustion, and soon causing the incinerator to be declared a nuisance. The charging of the dripping refuse on the highly heated brick further soon cracked them, requiring constant repairs and making the incinerator a most expensive and unsatisfactory method of disposing of the refuse.

Natural draft was alone employed in all these incinerators, and, in fact, is still being exclusively used by the American incinerator constructors, they having failed to profit by their numerous failures.

With natural draft it has been repeatedly demonstrated that it is impossible to maintain a sufficiently high temperature in any character of furnace for refuse disposal, however perfect may be the construction of the furnace itself. For complete combustion a high temperature must be used, that is, a temperature of 2000 degrees F., and to maintain this high temperature a mechanical draft must be employed, either forced or induced, or both. Only when the present designor or constructor of incinerators in this country recognizes this well-known fact, will incineration cease to be an experiment with us.

.The American engineer leads the world in whatsoever

he undertakes, and when the task of installing properly constructed incinerating plants is placed entirely in his hands by municipalities, then only will the health of the citizens and the interest of the taxpayers be protected, the same as is done in all other countries.

Incineration in this country has now passed through those stages through which it was forced to pass in other countries before it became the only successful method of refuse disposal, and with our many past failures as a lesson the time has arrived when it can be likewise made a success in this country.

A great deal of work and money has been and is now being expended with this object in view, and for a city to now consider any other method of refuse disposal is to invite further delays, and the waste of public money. The following are some of the leading American companies who have, or will ultimately produce a successful incinerator for the disposal of American refuse:

Decarie Manufacturing Co., of Minneapolis, Minn.
Dixon Garbage Crematory Company, of Toledo, Ohio.
Engle Crematory Co., of Des Moines, Iowa.
Lester-Vanderlip Furnace Co., of New York City.
Lewis & Kitchen, of Chicago, Ill.
Morse-Boulger Destructor Co., New York City.
National Equipment Co., St. Louis, Mo.
Sanitary Engineering Co., New York City.

The following official reports from leading American cities give the present method adopted by them for disposing of their waste, and with what success.

From these reports it can be seen that the future success of waste disposal in this country depends upon the incineration of all the combustible waste, and the reduction of the remainder.

LIST OF AMERICAN CITIES REPORTING THEIR PRESENT METHOD OF REFUSE DISPOSAL.

Akron, Ohio.
Alton, Ill.
Apalachicola, Fla.
Allegheny City, Pa.
Antigo, Wis.
Atlanta, Ga.
Atlantic City, N. J.
Allentown, Pa.
Buffalo, N. Y.
Brunswick, Ga.
Boulder, Colo.
Baltimore, Md.
Boston, Mass.
Brownsville, Tex.
Chicago, Ill.
Corsicana, Tex.
Cincinnati, O.
Champaign, Ill.
Cleveland, O.
Covington, Ky.
Concord, N. H.
Danbury, Conn.
Deadwood, S. D.
Dallas, Tex.
Detroit, Mich.
Evansville, Ind.
Evanston, Ill.
Fort Dodge, Ia.
Fort Wayne, Ind.
Houston, Tex.
Hornellsville, N. Y.
Indianapolis, Ind.
Joliet, Ill.
Keokuk, Ia.
Los Angeles, Calif.
Lancaster, Pa.
Louisville, Ky.
McKeesport, Pa.
Memphis, Tenn.
Minneapolis, Minn.
Norfolk, Va.
New Castle, Del.
New York, City of.
Oskaloosa, Ia.
Pensacola, Fla.
Prescott, Ariz.
Paterson, N. J.
Philadelphia, Pa.
Portland, Ore.
Pittsburg, Pa.
Raleigh, N. C.
Richmond, Va.
Reading, Pa.
Skowhegan, Me.
Santa Rosa, Calif.
South Bend, Ind.
Syracuse, N. Y.
San Francisco, Cal.

CITIES REPORTING METHOD OF REFUSE DISPOSAL.
(*Continued.*)

Salem, O.	Trenton, N. J.
Sault Ste. Marie, Mich.	Tyrone, Pa.
South Framingham, Mass.	Utica, N. Y.
Staunton, Va.	Vincennes, Ind.
St. Louis, Mo.	Washington, D. C.
Troy, N. Y.	Wilmington, Del.
Tampa, Fla.	Waterbury, Conn.
Two Harbors, Minn.	Wheeling, W. Va.

ALTON, ILL. Population, 14,210

All garbage is sewered into the Mississippi river.

ALLENTOWN, PA. Population, 35,416

A Dixon garbage crematory was installed in this city in 1892, guaranteed to consume 25 tons of garbage every 24 hours. It is claimed that it will only consume about 18 tons in that length of time, and it is stated that there is a law suit pending relative to its inefficiency.

ATLANTIC CITY, NEW JERSEY. Population, 27,838

All garbage is disposed of by incineration, the plant being operated by the Atlantic Products Co., which company has a contract with the city both for the collection and disposal of all garbage, and it is stated is giving satisfaction.

ALLEGHENY CITY, PA. Population, 129,896

All garbage disposed of by the reduction method, the plant being operated by the Allegheny Garbage Co. under contract with the city, and it is stated is giving satisfaction.

AKRON, OHIO. Population, 42,728

Uses neither incineration or reduction, but all garbage collected and disposed of by private company.

ATLANTA, GA. Population, 115,000

This city disposes of all its refuse by incineration, having tried in the past 15 years several types of incinerators with more or less success.

The first incinerator erected by the Dixon Crematory Company was erected in this city in 1896, under a contract with the city by which the plant was to be operated one year before payment by the city.

While it is reported to have rendered excellent service during the year, the cost of its operation was considered excessive by the city.

In 1905 the city installed a Decarie Incinerator, which is reported to be giving satisfaction during the short time it has been in operation.

BOSTON, MASS. Population, 560,892

Under a contract with the New England Sanitary Product Co., which has a reduction plant on Spectacle Island, Boston Harbor, all garbage is collected by city teams and dumped at the water front into scows, which are towed by this company to its plant. During the year 1904 the city delivered 48,373 loads, averaging 2,500 lbs. per load, to this company.

BUFFALO, N. Y. Population, 352,219

This city disposes of its garbage proper by reduction and its waste by incineration. The garbage is collected and disposed of by the reduction process under a contract calling for the payment of $2.19 per ton. The Buffalo Sanitary Co. reduces all the garbage by the so-called

"Merz" system. For the fiscal year ending July 1, 1905, there was collected a total of 6,599 loads, weighing 23,701.7 tons, at a cost to the city of $51,905.32, or 13 cents per capita, for the collection alone. (U. S. Census, 1900.)

REFUSE DESTRUCTION.

On the other hand, the city collects miscellaneous refuse and has installed a refuse destroyer of the crematory type. The refuse is hauled to this destroyer, sorted, such recovery made as is possible, and then run on the belt into the furnace. The heat produced is used to operate a sewage pumping plant. The city has decided to erect two other destroyer plants. As the heat from these plants will not be taken for power, garbage will be destroyed in them. When these plants are in operation, the garbage will be collected and hauled to the municipal destroyers under contract at $1.55 per ton. During the year ending July 1, 1905, the city collected 181,000 cubic yards of refuse at a cost of $67,986.68.

COST OF COLLECTING ASHES.

The city collects all ashes. The cost of hauling, during the last year, was 31 cents per cubic yard. The amount collected was 184,000 cubic yards and the total cost $57,159.21. Commissioner Ward states that this item of ash collection is causing the city considerable worry because of the expense of hauling the ashes from apartment houses, office buildings, hotels, etc. The Common Council has decided that, after January 1, 1906, the municipal collection shall be "a civic domestic collection and is not intended to be extended to commercial trades or manufacturing institutions."

The total expense for the year ending July 1st for ashes, rubbish and garbage was $177,051.21, or, approximately, 44 cents per capita.

CREMATION FAVORED.

Commissioner Ward thinks that Buffalo will have adopted the best system when it has established its own destroyers and provided for collection under the contract system.

Mr. Ward also states that in Buffalo they consider cremation a better system than reduction because the reduction system creates a nuisance and requires the location of a plant in the suburbs. This, in turn, adds very greatly to the cost of the hauling.

THE MODEL CITY.

As I consider that the city of Buffalo has at present the best system of collection and disposal of all its refuse of any city in this country, I give the report of the Hon. Francis G. Ward, Commissioner, verbatim, viz.:

"Garbage is hauled to the Baynes Garbage Crematory at Cheektowaga, and reduced under the 'Merz' system.

Refuse is hauled to the City Destroyer on Main and Hamburg Canal site, and, after recovery of the valuable portion, destroyed in furnace.

Cost of collection, haulage and disposal of garbage, $2.19 per ton.

Three separate collections are required: Ashes, Refuse and Garbage.

Total cost of collection and disposal of garbage alone, $60.000.00, equal to 15 cents per head (400,000 inhabitants. Census, 1906).

This work is done under contract with the Buffalo San-

itary Company, who have a contract for a period of five years, ending July, 1908, at the following rates: 31c. cubic yard for collection and disposal of ashes, 37½c cubic yard for collection and disposal of refuse, $2.19 per ton for collection and disposal of garbage."

BRUNSWICK, GA. Population, 9,681

The city uses an incinerator for the disposal of dead animals and excrement from water closets which are outside of the sewerage limits. The plant was installed by the Engle Sanitary & Cremating Co. in 1889. Garbage and waste is burned in the open air on low places and the ashes are used for filling in same. All destructible matter being burned, the tin cans, broken glass, etc., become heated red hot and so purified, before being used for filling in purposes. The incinerator is giving satisfaction for the purpose it is used.

BOISE CITY, IDAHO. Population, 5,957

The city disposes of its garbage principally by dumping it into the river.

BALTIMORE, MD. Population, 508,957

All garbage disposed of under a contract with the Baltimore Sanitary Contracting Co., which company employs the Arnold-Edgerton reduction process, using 28 digestors of 10-ton capacity each, and seven steam roller presses.

The contract with this company includes the collection of ashes, miscellaneous refuse, dead animals and garbage, as well as the reduction of the latter, for which they get a lump sum of $200,000 per annum.

From the sanitary point of view, it is claimed that their reduction plant has given perfect satisfaction to the municipal authorities, but when separated from the collec-

tion part of the contract, that it is not financially profitable, as the cost of reduction is out of proportion to the value of the tankage.

Under their contract this company handles about 30,000 tons of garbage per annum which costs to reduce $1.15 per ton. As this cost of disposal is included in that of collection, it is therefore claimed that the contract is not profitable.

CHICAGO, ILL. Population, 1,698,575

This city has not yet been able to introduce the incineration system of disposing of its garbage. Sometime ago a small reduction plant was built at the Chicago House of Correction, as an experiment. Only a small amount of garbage was disposed of at same. The city dumps all refuse into a drainage canal, which discharges into Des Plaines river; 1,500 tons daily.

BOULDER, COLO. Population, 6,150

All garbage disposed of by dumping and then burning same. Other methods too expensive.

CHAMPAIGN, ILL. Population, 9,098

All garbage conveyed by the city to a dumping ground, where it is burned. Other methods too expensive.

CINCINNATI, OHIO. Population, 325,902

All garbage reduced by the Cincinnati Reduction Co., under a five-year contract with the city.

The Cincinnati Reduction Co. have the contract for the collection and disposal of all garbage, the system used being the Detroit Liquid Separation system. The company claims that they are satisfied with their contract, and from reports received they are giving satisfaction to the city.

CLEVELAND, OHIO. Population, 381,768

On Jan. 1, 1905, the city purchased from the Newburg Reduction Co. its entire plant and collection equipment, and since that time has been engaged in collecting and disposing of its own garbage. The price paid was $87,500, including fifty acres of land surrounding the plant.

Collections in the down-town or business section of the city are made daily, and in the outlying districts from two to three times per week. Householders are required to put the garbage in water-tight metal cans and place the same at a convenient point in the back yards, from which the collector takes it and empties it into iron water-tight wagon boxes. It is then hauled to a central loading station on the Baltimore and Ohio Railway, where by means of an electric crane the box is lifted from the wagon and placed upon a specially constructed railroad car and shipped to the plant located at Willow, Ohio, a distance of eight miles from the city. It is then hoisted from the car and dumped upon the receiving floor of the plant, after which it is shoveled into the digestors (of which there are 14), each holding five tons to a charge. Steam is then turned on, and when the garbage is cooked it is removed from the bottom of the digestor, and by means of a belt conveyor placed upon small cars and taken to the hydraulic presses where the liquids are squeezed out. This is then pumped to a vat and the grease skimmed off the top. The solids are conveyed to the dryer, and when dried and screened, are placed in sacks for shipment to fertilizing companies. This material brings about $7.00 per ton. The grease is sold to soap manufacturers at about 3c per pound.

Prior to 1905 the city paid the contractor $69,400 per

year for the collection and disposal of garbage. This year the council appropriated but $60,000 for this work. The sale of by-products have netted the city about $5,000 per month. The city has spent about $10,000 for additional equipment and increase of plant, and are erecting an addition to the present plant of 60 tons per day capacity, which addition was designed and is being erected by the Edson Reduction Machinery Co.

CORSICANA, TEX. Population, 9,313

The city has had in operation for the last 10 or 12 years an incinerator with complete success. All night soil, carcasses and garbage is consumed in it without odor, and at a most moderate cost.

COVINGTON, KY. Population, 42,938

All garbage is disposed of in an incinerator built by the Dixon Crematory Co. It is stated that the process is fairly satisfactory.

DALLAS, TEX. Population, 42,638

The city operates a Dixon incinerating plant for the incineration of dead animals and all refuse which would be objectionable on their dumping grounds. No night soil is incinerated. For the purposes used, it is stated that the plant is satisfactory.

EVANSVILLE, IND. Population, 59,007

The city has operated since 1896 an incinerator built by the Eagle Sanitary and Crematory Co. at a cost of $9,000. The furnace is an extra No. 4, with a capacity of 45,000 cubic yards per day. It is used solely for combustible refuse from stores and residences, consuming about eight tons per day. The plant has proved entirely

satisfactory. It is stated that only when the atmosphere is heavy is there any smell from the plant, and then not to an extent to cause objection.

EVANSTON, ILL. Population, 19,259

The city formerly operated an incinerating plant built by the John Pearce Co. as an experimental plant, in which only garbage and kitchen waste was destroyed. It is stated that while the above garbage was destroyed without any complaint as to odors, that the city found the cost of operation was too high, as the heat was not utilized. The city has now all waste removed four miles from city limits and plowed under, using part of same as feed for swine.

FORT DODGE, IOWA. Population, 12,162

The city uses a dumping ground for its waste, as the expense of any other method was found to be prohibitive.

FORT WAYNE, IND. Population, 45,115

The city operates an incinerating plant which was built by the Dixon Crematory Co. in 1896 at a cost of $8,000. In 1903 the building was partially destroyed by fire and was rebuilt and its capacity increased, at a cost of $2,600. Formerly natural gas was used for fuel, but owing to the failure of same, for the past two years coal has been used, which has increased the cost of operation. Only what is strictly classed as garbage is so destroyed, and it is stated that the plant has met all the requirements guaranteed, and is giving satisfaction.

The city makes a contract once a year for the collection and delivery of all garbage (except hotels, restaurants, public boarding houses and saloons) at the incinerating plant. The householder is required to provide proper receptacles for the garbage.

No attempt has been made to utilize the waste heat. The following report shows the cost of collection and disposal for the year of 1904:

Total number of loads collected	2,481
Number of working days	306
Average loads per day	8.11
Number of tons hauled by city wagons	4,953
Number of tons hauled by other wagons	2,216
Total number of tons incinerated	7,169
Average tons per day	23.44

EXPENDITURES.

Salaries, attendants	$1,713.33
Salaries, collectors	4,300.00
Salaries, scavenger	576.00
Coal	1,584.31
Repairs to wagons and tools	194.02
Fire brick, clay, lime, etc	366.73
Castings	113.05
Grate bars	138.28
Horse for scavenger	110.00
Horse feed	25.00
Gas	11.36
Repairs to building	10.95
Hose	10.50
Chain	4.95
Miscellaneous	17.65
Total	$9,176.13

INDIANAPOLIS, IND. Population, 169,164

The reduction method is used in this city. The plant was installed in 1897 by the Chamberlain Co. and is located at Seller's farm. A local company known as the Indianapolis Dessicating Co. has charge of the hauling of the garbage. It is stated that the reduction method has given satisfaction to the city, though both incinerator and reduction have recently been under consideration.

JOLIET, ILL. Population, 29, 353

All refuse is disposed of by incineration, the plant being erected by the Dixon Crematory Co. in 1900. Since that time it has been run continuously with the exception of three or four days' shut-down each year for the purpose of making repairs of fire-clay brick. For operating the plant two men are employed for the entire year at $1.75 per day each. The city appropriates $300.00 per annum for coal and a like amount for repairs for furnace. The average cost of collecting and delivering the garbage to the incinerating plant is 71 cents. It is estimated this could be reduced one-half if the plant was more centrally located, instead of outside the city limits. An average of eight tons of garbage per day, which is half the capacity of the furnace, is destroyed, about 100 pounds of coal being used to a ton of garbage.

Report for December, 1905, shows average cost of operation of this plant as follows:

Garbage hauled by city carts............	173¼ tons
Rubbish hauled by merchants and pkg. house	22½ "
Total amount consumed.................	195¾ "
Ashes hauled to near-by dumps............	969 "
Total amount of tons handled............	1164¾ "
Amount of coal consumed...............	5 1-3 "

Average amount coal per ton garbage.....	54¾ lbs.
Loads of paper, collected and destroyed (one cart only)	148 lds.
Loads of street sweepings collected..........	367 "
Cats cremated	3
Dogs cremated	55
Horses cremated	7

LOS ANGELES, CAL. Population, 102,497

This city is at present installing a Decarie incinerating plant which is expected to be in operation by Feb. 1, 1906.

LANCASTER, PA. Population, 41,497

This city disposes of all its garbage by the Davis incinerator, which is reported to be giving satisfaction.

LOUISVILLE, KY. Population, 204,731

An incinerating plant was installed by the Dixon Crematory Co., but was closed by injunction upon the claim that it was a nuisance before the plant was operated sufficiently long to determine anything as to its merits.

Judgment was rendered for the plaintiff in the lower court and affirmed by the Court of Appeals.

It was claimed that the contractor guaranteed to dispose of 80 tons per day, but actually disposed of only about 30 tons at a cost of about $35.00, or $1.16 per ton.

By some it was claimed that the process itself was at fault, while others contended that the entire trouble was due to the fact that the householders would not separate the ashes, etc., from the garbage, though there was an ordinance compelling proper separation. It was stated that the contractor operated the plant for six months and then discontinued it, the city purchasing the plant for $22,000, and after ten days' trial, compelled to shut it

down by order of the court. It was claimed that the odors emanated from the plant were noxious and offensive, so that the city lost a suit for damages.

It is generally believed that the process of separation was largely responsible for the odors and not due to any defect in the plant itself, but the plant was finally abandoned in April, 1891, and the city since that time has been dumping its garbage in the low lands. Individuals may, if they so desire, haul away their own garbage, but garbage must be brought to one of the regular city "dumps."

The hauling of garbage, ashes, rubbish, etc., is done by the Street Cleaning Department, the total cost for hauling being about 53 cents per load.

The carcasses of dead animals are sold to a contractor, who buys same outright from the owner, the average price paid for horses being about $3.00.

MILWAUKEE, WIS. Population, 285,315

This city disposes of its garbage by incineration; the plant being erected by the Engle Sanitary and Cremation Co.

MINNEAPOLIS, MINN. Population, 202,718

This city uses the Decarie incinerating system, and reports that it is disposing of its garbage in a sanitary manner.

MCKEESPORT, PA. Population, 34,227

The city operates its own incinerating plant, which is giving satisfaction. The incinerator was installed by the Clinton Foundry & Machine Co.

MEMPHIS, TENN. Population, 102,320

For some time past all garbage has been incinerated, and while it is reported to have been a very satisfactory

disposition of the garbage, the cost of keeping the incinerators in repair has been so great that the city is now considering the question of dumping the garbage into the Mississippi river.

The incinerators now in use were installed by the Dixon Crematory Co. and it is stated, except for the fact that they are so much injured by the heat that they are very satisfactory.

NEW YORK, N. Y. Population, 3,437,202

There are two incinerators at work in this city for the disposal of light refuse, by which is meant waste paper, old furniture, etc., etc. At the largest plant 150 loads are disposed of daily, while at the smaller plant, there are about 100 loads.

The Sanitary Utilization Company disposes of about 880 tons of garbage or food waste per day. This is done by means of digesters and compressors. The grease or fatty substance is extracted and the residue utilized for fertilizing purposes. The incinerating plant is located at Forty-seventh street, North river, furnishing light for the new Williamsburg bridge. This plant cost $31,000 and the electric lighting station $50,000. The incinerator has a capacity of 350 cart loads of 7 cubic yards every 24 hours, each load weighing about 1,000 lbs., and the heat derived therefrom operates the 400 h. p. installation of boilers.

The incinerator is housed in a one-story building 70x 150 feet with a front space where the rubbish carts discharge their loads on a metallic conveyor. This carries forward the rubbish between sorting boxes, where the material is trimmed or sorted by hand as it passes. The unmarketable rubbish remaining on the conveyor is car-

ried over the cross wall and discharged from the conveyor upon a fire-proof platform, above the furnaces.

The street sweepings carts drive up a roadway on the outside of the building at the rear to a fire-proof platform and there deposit their load. The material deposited on the platform by the conveyors and the street-sweeping carts is pushed into hoppers which empty into the furnaces. The hot gases of combustion pass through a horizontal flue into the stack, the rubbush burning without the aid of any other combustible. When steam is to be generated the gases are sent through the boilers, and thence to the stack.

Steam from the boilers is carried through an 8-inch main steam line to the electric lighting station, a building 20 feet away, with outside dimensions of 50x60 feet, in which is installed three engines, each engine direct connected to a generator supplying 240 volts current. There is one feeder for station building lighting, one for incinerator building lighting, and five feeders for bridge service, with the probability of other feeders being added, all of the feeders carrying light to some part of Greater New York.

The incinerator is constructed of red brick lined with fire brick, in which a temperature of 2,000 degrees Fahr. is maintained. Natural draft is used, the stack being 114 feet in height. From a test, it was found that one pound of refuse would evaporate 1.5 pounds of water, producing 232.7 h. p. per hour.

COLLECTION.

The city bears the entire expense of the collection of all refuse.

The driver of a garbage wagon is assigned to a speci-

fied route, the average length of which is approximately one mile. He is required to remove all ashes, garbage and street sweepings on his route. The garbage is collected between certain hours in the morning, and the ashes and street sweepings are gathered during the remainder of the day. His hours are from 6:30 a. m. until his route is cleaned. If he gets through before 4 p. m. his route is increased.

The ashes are put outside the house in one can, and the garbage placed outside in another can.

The paper cart driver collects the light rubbish along his route. Each house is supplied with a "P. and R." card, which is displayed in a place where it may be easily seen by the driver. The displaying of this card means that there is light rubbish in the house for which the driver is to call.

There are 1,316 drivers in Manhattan, the Bronx and Brooklyn.

The horses travel an average distance of 20 miles each day. The driver is not allowed to trot his horse.

GARBAGE CART.

The ideal style of ash and garbage cart is one that will hold a proper size load; that is water-tight on sides and bottom; that is strong and light; that will tip at the dumping boards; that will prevent the ashes from blowing about the streets when loading and going to the dumping place. Every wagon should be thoroughly cleaned and disinfected with hot water each trip.

The apparatus used by the city of St. Louis, described in this work, is giving perfect satisfaction for such work.

THE SALABLE ARTICLES RECOVERED AT A NEW YORK REFUSE DISPOSAL STATION.

Material Sold from 18th Street Yard in 1899.

Manila paper, pounds	461,385
Newspaper, pounds	905,301
Mixed paper, pounds	442,866
Strawboard, pounds	587,208
Mixed wrapping paper, pounds	635,136
Books, pounds	18,620
Woolen rags, pounds	18,617
White rags, pounds	41,450
Mixed rags, pounds	116,550
Black rags, pounds	200,495
Bagging, pounds	48,055
Twine, pounds	21,070
Soft back carpet, pounds	18,795
Hard back carpet, pounds	79,820
Wool carpet, pounds	3,915
Linsey carpet, pounds	7,180
Rough cloth and old coats, pounds	20,945
Stockings, pounds	4,600
Shoes (bulk), pounds	38,160
Shoes, pairs	1,435
Siphons	603
Siphon heads	21
Quarts	1,995
Lagers	18,759
Sodas	7,751
Weiss	104
Iron (scrap), pounds	80,800
Mixed bottles, barrels	350
Hats	2,100

SALABLE ARTICLES RECOVERED. (*Continued.*)

Curled hair, pounds	765
Copper, pounds	494
Zinc, pounds	2,090
Brass, pounds	1,607
Lead, pounds	303
Rubber shoes, pounds	4,712
Rubber mats, pounds	2,712
Rubber hose, pounds	1,255
Rubber (white), pounds	1,090
Hair cloth, pounds	400
Large bottles, pounds	64
Tin cans, loads	12
Excelsior, pounds	260
Bed springs	16
Mattresses	36
Brushes, dozen	1

There were 116,000 persons in this district, including the occupants of all classes of city buildings, dwellings, tenement houses, department stores, shops, factories, etc.

PITTSBURG, PA. Population, 321,616

The city lets a contract annually to the American Reduction Co. for the removal of all garbage, the cost approximating $160,000 annually.

PORTLAND, OREGON. Population, 90,426

The city operates an incinerating plant for the destruction of all garbage, which was installed seven years ago by the Engle Co., but it is reported not to be giving satisfaction, being too wasteful of fuel. The cost is checked daily by use of a pair of platform scales, and will average not less than $1.60 per ton to destroy. Between twenty and thirty tons are destroyed daily.

The city has now under consideration the purchase of a more economical incinerator.

PHILADELPHIA, PA. Population, 1,293,697

All garbage is disposed of by reduction, under a contract with the American Product Co., which company employs the "Arnold system improved" process of reduction. It is reported that the process is giving satisfaction. The cost for removal and disposal of garbage for the year 1905 was $560.000. For 1904 the contract price was $536,700, and 224,256 tons were handled.

RICHMOND, VA. Population, 85,000

This city has in operation an incinerator installed by the Eagle Sanitary Co., guaranteed to destroy 75 cubic yards of miscellaneous garbage, refuse and dead animals each day, which capacity is 15 loads of one cubic yard each at one time, and the daily capacity is calculated to be sufficient to destroy all the present daily collection of the city, including summer, when the quantity is greater than the above amount.

RALEIGH, N. C. Population, 13,643

The city owns a farm of 200 acres near the city, on which it has sanitary headquarters, as well as stables. All garbage waste is dumped on this farm, which is carried on as a farm on a small scale. There is sufficient grain raised on same to provide feed for the stock.

READING, PA. Population, 78,961

All garbage is disposed of by reduction, which plant was installed three years ago by the Reading Sanitary Reduction Co., employing the Eddgerton system. The plant is located three miles outside the city limits, and is reported to be a profitable investment. This company both collect and reduce the garbage for $2.24 per

net ton, the city paying the expense of the weighmaster and furnishing the scales. This work comes directly under the supervision of the Department of Garbage and the City Engineer.

SAN FRANCISCO, CAL. Population, 450,000

The Sanitary Reduction Co. have been operating an incinerating plant under a contract with this city since 1896. By city ordinance all character of refuse is required to be delivered at this plant, the company under their contract receiving 20 cents per cubic yard for the incineration of same, and the city and county receiving 2 per cent rebate.

The ordinances under which this contract was let, and those providing for the collection and delivery of all refuse at this plant, and prohibiting the dumping of garbage on the streets, highways, empty lots and waterways, were the subject of litigation for several years, being tried in U. S. Circuit Court, approved by the U. S. Court of Appeals, and finally affirmed by the U. S. Supreme Court, fully sustaining the legality of the ordinances.

The franchise of this company grants to it the exclusive right of cremating and disposing of all garbage produced in San Francisco, with the privilege of charging the above named price of 20 cents per cubic yard, which means a charge of 60 cents per year for every household, business house or hotel in that city, or about 15 cents per capita, allowing four persons to a family, as can be seen from the following data:

In the year 1894 there were by statistics in San Francisco 99,659 houses, 17,660 of these houses being one story, the balance two, three, four, five and higher story houses, and there were 23,591 stores, saloons, factories,

laundries, hotels, shops, mills, etc. This would make the cost of entire refuse disposal 4¾ cents per month for each, or 57 cents per annum. For the year 1905, the number of residences had increased to 198,865, making for that year 60 cents per annum, the price paid for the burning of all garbage from the smallest cottage to the largest hotel.

For the year **1905** the total cost of refuse disposal was as follows, viz.:

For burning all refuse	$46,388.26
City and county for taxes	564.21
Legal expenses defending suit in U. S. Supreme Court	1,516.20
City and county 2 per cent of gross receipts for burning garbage	1,175.76
Office expenses and directors' fee	1,780.00
Depreciation of plant	10,000.00
Total	$61,424.43
Leaving net earnings	2,365.87
Total	$63,700.30

At 20c per cubic yard, and allowing 3.87 cubic yards to a wagon holding 1½ tons, this would make the cost of incineration about 51 cents per ton.

In spite of the violent opposition, this company has disposed of all waste, irrespective of its character, with satisfaction to the citizens and the approval of the city officials.

The company has never paid a dividend upon the capital of $500,000 invested. For ten years, it is stated, that these stockholders have been without any interest for their

money, but it is generally admitted that this company has not only been the means of giving the city a good sanitary system, but also of providing work for several hundred laborers.

The company is so well satisfied with the success of incineration that they have now under consideration the building of a more modern incinerating plant, in order to utilize the waste heat therefrom, for power and electric lighting. When this is done, there can be no doubt but that this company will meet with the financial success it evidently deserves.

SAVANNAH, GA. Population, 54,244

The Engle system of incineration was used for quite a time. It is reported that the results were not thoroughly satisfactory, and after the plant was fairly worn out, it was abandoned.

The city garbage and waste is now taken out of the city on special cars by the electric railway, to the poor farm of the county, where it is handled by convict labor.

SANTA ROSA, CAL. Population, 6,673

The city incinerates its garbage in a plant built by itself, in which only the dry garbage is burned. They do not attempt to burn the kitchen garbage, and the plant in a small way is reported to be satisfactory.

SOUTH, BEND, IND. Population, 35,999

The city disposes of its garbage by incineration in a plant built by the Dixon Crematory Co. It is reported to be satisfactory to date.

STAUNTON, VA. Population, 7,289

Staunton does not dispose of its garbage by reduction or incineration. The matter as to what is the best dis-

position to make of garbage and waste has given the city officials no little trouble of late.

ST. LOUIS, MO. Population, 700,000

At present the city is disposing of all its refuse by dumping it on Chesley Island, which is an island in the Mississippi River, 15 miles below the city, where it is fed to swine.

The present cost of collection and disposal is estimated as follows:

Amount of refuse collected per annum......70,000 tons.
Cost of collection at $1.67 per ton..........$116,900.00
Cost of disposal at one dollar per ton........$ 70,000.00

Total annual cost for handling refuse.....$186,900.00

An ordinance providing for the incineration of all refuse has been approved by the Board of Public Improvements, and is now pending in the City Council.

Until 1902 the city disposed of all its refuse under a contract with the St. Louis Sanitary Co., which company employed the Merz process of reduction.

This contract was annulled by the courts.

The reduction works of this company, it is stated, originally cost $275,000, including the land. The daily average capacity of the plant was 226 tons. It contained the following machinery:

Twelve 125 horse power horizontal tubular boilers;
One 250 horse power Corliss engine;
One 36 horse power engine and one 250 three c. p. light dynamo;
One 60 horse power fan engine;
One 75 horse power engine for bone mill and screens;
Three duplex pumps, capacity 525,000 gallons;

Two small pumps, capacity 225,000 gallons;
Five No. 8 Garden City fans;
Sixteen Eureka driers;
Four Preston digestors, 8½ feet diameter by 14 feet high;
Eight garbage receiving tanks;
One Otis engine and elevator; mill screens, conveyors, elevators, rectifying tanks, oil pumps, etc.

The city paid this company for the disposal of all its refuse at a stipulated price per 100 lbs. irrespective of the character of the same.

It is claimed that with the best business management, and no expense spared in its operation, that the company could barely make expenses.

SYRACUSE, N. Y. Population, 108,374

For almost ten years the green garbage collected in the city has been treated by a reduction process known as the Holthaus system. The plant is operated by the Syracuse Reduction Co., a private corporation, which is under contract to reduce all of the garbage delivered at the plant by the city for an annual charge of $26,000,00. It is stated that the plant successfully disposes of all of the garbage produced in the city, the collection varying from 35 tons daily in the winter, to upwards of 50 tons in the summer.

TAMPA, FLA. Population, 15,839

The city has in operation an incinerating plant of 25 tons capacity, erected by the Decarie Mfg. Co.

TRENTON, N. J. Population, 73,307

The city is operating at the present time an incinerating plant installed by the Davis Garbage Furnace Co., which

consists of two furnaces of 25 tons capacity each, which plant has been in operation five years, and it is stated giving entire satisfaction.

TROY, N. Y. Population, 60,651

The city has disposed of its garbage for the past twelve years, using the Brown furnace. It is still in good repair, and it is stated that the work is satisfactory in every way.

TYRONE, PA. Population, 5,847

The city sewers all garbage into the river, and it is reported they will continue to do so until stopped, which is not feared for some time to come.

UTICA, N. Y. Population, 56,383

The reduction system is operated by a contractor, Henry Stappenback, the Arnold system being used, and it is reported has always given good satisfaction.

VINCENNES, IND. Population, 10,249

The city uses a reduction plant installed by Kellersohn & Wirth, which plant is operated by a private company. All garbage, including animal matter, is reduced. Night soil is not reduced. The plant is working satisfactorily.

WHEELING, W. VA. Population, 38,878

The city owns and operates an incinerating plant, which was originally installed by the Dixon Crematory Co., but it has been remodeled on different lines several times since.

WATERBURY, CONN. Population, 45,859

The city disposes of its garbage, etc., by means of an incinerating plant, which was installed by the Bridgeport Boiler Co., using the Smith furnace.

WILMINGTON, DEL. Population, 76,508

The city operates an incinerating plant for the disposal of its garbage, which was built at a cost of about $20,000; the maintainance of which is about $15,000 per annum.

A Brown incinerator is used, and the evident source of this great expense is the brick lining of the furnace and the use of an auxiliary furnace.

The city has now under consideration the abandonment of the incineration method, and the installation of a reduction plant.

The city is operating the incinerating plant, but has in contemplation the letting out of the reduction proposition on contract.

WASHINGTON, D. C. Population, 278,718

The city has tried various methods and systems for disposing of its garbage. The first incinerator installed was the Brown incinerator. This one burned down and a Smith incinerator was installed. Both of these it is stated failed to give satisfaction and were discontinued.

The city then dumped into the Potomac river until stopped by the City of Alexandria. For four years the garbage was then dumped on a farm and used as a fertilizer, until the State of Maryland prohibited same.

At present all garbage is disposed of by the Chamberlain process of reduction under a contract with the Washington Fertilizer Co. Ashes and other waste are deposited on the public dumps described below.

Paper and other saleable refuse is disposed of at the picking plant recently erected by the contractor for the collection and disposal of that class of waste, while the non-saleable waste material, other than ashes, is burned at the above picking plant. The cost and method of op-

eration can be seen from the following extracts taken from the annual report of the superintendent, for the fiscal year ending June 30, 1905:

Statistical Summary.

PUBLIC DUMPS.

Number, maximum to minimum	11-8
Street sweepings received, loads	25,845
Ashes received, loads	72,680
Earth received, loads	42,937
Total loads received	141,462
Total cost	$4,876.72
Cost per load of material received	0.0345

The dumps controlled by this department decreased from 16 to 11 in 1904, and from 11 to 8 in 1905. Even with the limited number now in use there is almost constant opposition manifested on the part of neighboring property owners, and a recurring agitation for the removal of all department dumps to points distant from the city. This has heightened, and will continue to do so, the contract price for the removal of ashes, as well as, directly, our own cost of street and alley cleaning. With the marked outward spread taken by Washington's population in the past ten years our hauls have been correspondingly increased, and within another five years it may be necessary to use street railway transportation to outlying parts of the District from temporary storage stations within the city proper.

To overcome, so far as is possible, our manifest disadvantages over the excavation contractors who offer clean earth to owners of low lands, I am restricting the dumping privileges to such private carters only as bring in ashes reasonably free from paper and other rubbish. The

new ash-removal contract also provides, on the part of householders, for a strict separation from the ashes of tin cans, old kitchen ware, boxes, and the like, all of which in the past have constituted the chief cause of the unsightly appearance of our dumps and the unpopularity of ashes as a good filling material. In addition, an attempt has been made to improve the appearance of the present dumps by covering unsightly slopes so that vegetation could secure a start, and by burying objectionable material under fresh deposits of clean ashes smoothly leveled off.

CITY REFUSE COLLECTION AND DISPOSAL.

This estimate is made up as follows, the amounts set opposite the five different classes of refuse being the actual rates of the contracts entered into under authority of the act approved January 27, 1905:

Collection and disposal of garbage	$78,400.00
Collection and disposal of dead animals	2,360.80
Collection and disposal of ashes	54,000.00
Collection and disposal of miscellaneous refuse	16,500.00
Collection and disposal of night soil	16,500.00
Incidental expenses:	
Livery 2 horses and buggies for inspectors.	480.00
Repairs to bicycles, stationery and printing	100.00
Total	$168,340.80

The lowest bids received were much higher than the old contract prices. Compared with the expenditures in the past fiscal year they show an increase of $69,270, or about 70 per cent. Of this sum, $14,000 represents increasing the ash collections from once to twice weekly

during the winter months. A detailed comparison with the old contract prices is shown by the following table:

Classes.	1905.	1906.	Increase (+) or decrease (—).
Miscellaneous refuse	$8,000.00	$16,500.00	+$8,500.00
Ashes	29,979.00	54,000.00	+24,021.00
Night soil	17,000.00	16,500.00	— 500.00
Garbage and dead animals	a43,511.00	80,760.80	+37,249.80
Total	98,490.00	167,760.80	+69,270.80

(a) Contract price of $51,600, less $8.089 in rebates to June 30, 1905.

Over $37,000 of the total increase is for garbage and dead animals. The present contractor has unquestionably lost money, and, whether because of this or of poor management, the service rendered during the five years of the contract has been notably poor. The bidders on the collection and disposal of ashes had to face the ever-growing scarcity of dumps and the much greater hauls necessitated. It is estimated that at the end of five years there will not be a piece of ground left nearer than Bennings on which ashes will be permitted by the owners or by the organized bodies of citizens in the neighborhood. It is also a fact that about 25 per cent of the householders have not availed themselves of the ash service. This increase is liable at any time to be thrown upon the contractor as prices for private collection rise and as the contractor's service under the new specifications is made regular and efficient. Other reasons applying to all the increases are: The normal growth in population in the five years since the present contracts were let and a marked spreading out of this population to parts of the District of Columbia outside the old boundary; the higher prices for labor and the greater cost of feed and supplies; the fact that the former contracts for ashes and rubbish are the first ever entered into by the District, and that the

householders in general were slow in availing themselves of the public service; and, finally, that the new specifications were advisedly made more rigid in the determination to secure a better character of service throughout.

The following is the form of notice used:

NOTICE TO HOUSEKEEPERS.

GARBAGE, ASH AND REFUSE COLLECTIONS.

Street Cleaning Department,
District of Columbia.

SIR: In order to secure and maintain a satisfactory collection service, it is necessary that you comply strictly with the following synopsis of article 14 of the police regulations. Thereafter, please report promptly to this office any failure on the part of the contractor.

HARRISON STIDHAM, *Superintendent.*

Definitions.—"The word 'garbage,' wherever it occurs in these regulations, shall be held to mean the refuse of animal and vegetable food stuffs, except oyster and clam shells from business places."

"The term 'ashes' shall be held to mean ashes from coal and other fuels, and will include such mineral substances as fallen plastering, etc., as may accumulate in connection with the ordinary conduct of dwellings, but not such as may result from building operations."

"The term 'miscellaneous refuse,' under these regulations, means all rubbish and refuse (other than ashes, garbage, dead animals, and night soil) incident to the ordinary conduct of the household. It will be held to include discarded floral decorations, Christmas greens, and small branches from shrubs and vines, but not any cut grass; nor does it include loam, wall paper, or other

substance that may accumulate as the result of repairs to yards and dwellings or of other building operations."

Receptacles.—Garbage shall be placed in tight metal receptacles, having a cover and handle, of a capacity of not less than 3 nor more than 10 gallons.

Ashes shall not be placed in receptacles other than metal, of a capacity of not less than 10 nor more than 24 gallons, nor in more than one receptacle containing less than 20 gallons.

Miscellaneous refuse shall be placed in suitable receptacles that can be easily handled by one man. Paper and other light refuse, likely to be scattered or blown about, if bundled, tied, sacked, or otherwise properly secured, need not be placed in receptacles.

Garbage, ashes, and refuse must be kept dry.

Accessibility.—Receptacles containing garbage, ashes, and refuse shall be made easily accessible to the collectors on collection days between the hours of 7 a. m. and 6 p. m. The term "easily accessible," as herein used, means that receptacles shall be placed on the premises at or near the rear or side gate, if collections are made from the rear or side, and in front areaway or other convenient place near to the front entrance, if collections are made from the front.

General instructions.—"Owners and occupants of premises having street and alley entrances, and from which material is to be removed, shall place and cause to be kept placed conspicuously at the side and rear alley entrance thereof, the street and number designations in letters and figures, respectively, not less than 2 inches in height, so as to be easily read."

"No person shall alter, deface, remove, or destroy, any name of any street or number required to be displayed by these regulations."

"Receptacles containing garbage, dead animals, ashes, or miscellaneous refuse shall not be placed or left for collection upon any sidewalk, street, avenue, alley, or public place in the District of Columbia."

"It shall be unlawful to place or cause to be placed together in the same receptacle two or more of the above classes of material, and where such mixture results it shall be properly separated by the occupant of the premises."

"Any person violating any of the provisions of this article shall, on conviction thereof, be punished by a fine of not less than one nor more than forty dollars."

	1905.	1904.
Garbage and dead animals:		
Garbage collected and disposed of, tons..	36,417	32,282
Dead animals collected and disposed of, number	9,593	9,432
Contract price, collection and disposal...	$51,600.00	$51,600.00
Extra services	$120.00	$88.00
Deductions—		
For neglect	$3,692.00	$723.00
For rebate, at 50 cents per ton........	$8,208.68	$6,141.00
Total deduction	$11,900.68	$6,864.00
Net cost to District..........	$39,819.32	$44,824.00
Cost per ton, removal of dead animals included	$1.09	$1.39
Ashes:		
Loads by District contractor only.......	22,794	17,257
Cubic yards—ditto	91,176	69,028
Contract price, collection and disposal...	$29,979.00	$29,979.00
Deductions for neglect..........	$591.00	$176.00
Net cost to District..........	$29,388.00	$29,803.00
Cost per cubic yard, collection and disposal	$0.32	$0.43

	1905	1904
Miscellaneous refuse:		
Bags of paper by District contractor....	155,416	139,215
Cubic yards of trash received from private haulers	14,294	(a)
Contract price, collection and disposal..	$8,000.00	$8,000.00
Deductions for neglect..................	$89.00	$17.00
Net cost to District.....................	$7,911.00	$7,983.00
Cost per bag of paper collected and disposed of	$0.051	$0.057
Night soil:		
Privies cleaned	26,483	20,819
Contract price, collection and disposal...	$17,000.00	$17,000.00
Deductions for neglect..................	$24.00	None.
Net Cost to District....................	$16,976.00	$17,000.00
Cost per privy cleaned..................	$0.60	$0.82
Ashes and rubbish from District buildings:		
Loads removed	3,378	2,427
Cubic yards	6,756	4,854
Contract rate per cubic yard............	$0.38	$0.34
Total cost, distributed among the District departments availing themselves of this service......................	$2,567.00	$1,650.00

SOME RECENT INCINERATOR BIDS WITH ACCOMPANYING GUARANTEES.

GRAND RAPIDS, MICH. Bids opened Nov. 27, 1905.

DECARIE MANUFACTURING COMPANY,
Minneapolis, Minn.

(1) New steel building, with one Double Decarie Patent Garbage Incinerator, of 80 tons capacity per day of 24 hours, together with a down-draft furnace with steam-producing appliances, guaranteed to develop 600 horse power......$45,000

(2) Old building, with one Double Decarie Patent Garbage Incinerator, of 80 tons capacity per day of 24 hours........................$40,000

Guaranteed to dispose of "kitchen garbage, combustible refuse and rubbish and dead animals * * * without emitting from the smoke stack or incinerator any noxious odors or gases, and at a cost per ton not to exceed fifty (50) cents, including labor and fuel."

City must pay on contract:

- 50 per cent within 8 days after delivery of material.
- 40 per cent when plant is completed and ready to operate.
- 10 per cent when plant is accepted.

THE DIXON CREMATORY COMPANY, *of Toledo, O.*

(1) Remodeled present crematory, installing a Dixon Direct Draft Garbage and Refuse Cremator, of 40 tons capacity per day of 24 hours..**$16,398**

(2) Remodeled present crematory, installing a Dixon Forced Draft Steam-producing Garbage and Refuse Cremator, of capacity as above.... **25,100**

(3) A new fire-proof building, installing a Dixon Forced Draft, Steam-producing Garbage and Refuse Cremator, of capacity as above....... 36,480

(4) A new building, installing a Dixon Direct Draft Garbage and Refuse Cremator, of capacity as above............................ 19,824

Guaranteed to dispose of "mixed miscellaneous garbage, kitchen offal, refuse, slops, dead animals, animal and vegetable matter, condemned fruits, combustible waste, etc., etc., in a sanitary and inoffensive manner."

City must pay on contract:

50 per cent upon delivery of the material.
40 per cent upon completion of plant.
10 per cent after test and acceptance.

LESTER-VANDERLIP FURNACE CO., *of New York City*.

Three Lester-Vanderlip garbage destructors, of capacity of 80 to 120 tons per day of 12 hours, with three 150 h. p. water tube boilers, with flues, blowers, fans, etc., for producing 4,000 net h. p. per day, at actual cost, plus $5,055.19, the actual cost guaranteed to be within 5 per cent of estimate, $20,217.95. Total estimate $25,273.14

New building to be constructed by city according to plans furnished, at estimate cost of.. 20,000.00

Engines, dynamos and building to be constructed by city for generation of electric current for 250 lamps of 350 watts each for 12 hours per day, at estimated cost of...... 22,000.00

Total cost of plant estimated at........$67,273.14

Guaranteed "to incinerate 80 tons of house refuse garbage, trash and dead animals in 12 hours * * * * without the use of any fuel other than the garbage and refuse, and to accomplish this without odor or smoke at a labor cost not to exceed 38 cents per ton."

Every thirty days city must draw warrant for money expended, and pay the $5,055.19 final payment within thirty days after the plant is completed.

LEWIS & KITCHEN, *of Chicago, Illinois.*

New fire-proof building, with one garbage crematory of capacity of 80 to 100 tons per day:

"S" type, proposal "A"	$18,600
"S" type, proposal "B"	21,000
"B" type, proposal "C"	19,533
"B" type, proposal "D"	21,933
Series burning type, proposal "E"	21,140
Series burning type, proposal "F"	23,540

Cost of incineration per ton, "A," 45 cents; "B," 35 cents; "C," 45 cents; "D," 35 cents; "E," 40 cents; "F," 30 cents.

The crematories are arranged so that while one division is being operated for combustion at high temperatures, one or two others are used for drying.

SANITARY ENGINEERING COMPANY, *of New York City.*

A new building, with crematory of 80 tons capacity per day of 16 hours	$35,000

"The cost of operation shall not exceed 50 cents a ton for garbage and swill incinerated," when crematory, or one pair of cells, is burning at full capacity. If sewer connection is provided, cost will be reduced by 30 cents per

ton of fluid drained off. "The cost of incinerating miscellaneous refuse shall be less than that of incinerating garbage."

City must provide for "payments of reasonable amounts" during the progress of the work, and the balance within thirty days after the tests have been completed.

RACINE, WIS. Bids opened Jan. 13, 1906.
For a 25-ton incinerator.

Morse-Boulger Co., New York, N. Y., $9,900.

Smead & Co., Cincinnati, O., $5,650.

Decarie Mfg. Co., Minneapolis, Minn. (2 bids), $14,128 and $13,464.

Lester-Vanderlip Furnace Co., New York, N. Y., $12,000.

Dixon Garbage Crematory Co., Toledo, O. (5 bids), $9,860, $9,905, $8,830, $8,758 and $6,998.

Lewis & Kitchen, Chicago, Ill. (4 bids), $6,450, $7,650, $7,460 and $8,020.

Sanitary Eng. Co., New York, N. Y. (3 bids), $9,127, $7,150 and $10,630.

LEXINGTON, KY. Bids opened Jan. 4, 1906.
For a 50-ton incinerator.

Dixon Garbage Crematory Co., Toledo O. (4 bids), $12,610, $11,644, $11,999 and $11,036.

Decarie Mfg. Co., Minneapolis, Minn. (4 bids), $20,600, $21,960, $19,640 and $20,842.

Lewis & Kitchen, Chicago, Ill. (4 bids), $12,870, $13,785, $18,750 and $19,875.

Lester-Vanderlip Furnace Co., New York, N. Y., $16,000.

Morse-Boulger Destructor Co., New York, N. Y., $15,800.

Geo. H. Pierson, New York, N. Y., $18.000.

National Equipment Company, St. Louis, Mo., $22,000.

Smead & Co., Cincinnati, O., $5,650.

Sanitary Engineering Co., New York, N. Y., $14,217.

Sanitary Reduction & Constr. Co., Boston, Mass., $35,000.

Engle Crematory Co., Des Moines, Ia. Royalty.

DETROIT, MICH. Bids opened Dec. 11, 1905.

For a 200-ton incinerator.

Report of the Hon. Controller to City Council on same.

To the Honorable the Common Council:

Gentlemen—In response to advertisements from this office inviting proposals for furnishing the City of Detroit with a municipal garbage disposal plant or plants having an aggregate capacity of 200 tons per day, the following were received:

Dixon Garbage Crematory Co., Toledo, Ohio—Four 50-ton plants, $80,000.

Detroit Sanitary Works—Plant at French Landing, Mich., increased to 200-ton capacity, including 13 acres of land and seven 2-story workmen's houses, $100,000.

Lewis & Kitchen, Chicago, Ill.—Plants of 100-ton capacity:

Proposal A—Storage capacity 50 tons, one plant, $26,540; two plants, $51,600; cost of cremation, 45c per ton.

Proposal B—Storage capacity 60 tons, one plant, $31,860; two plants, $59,800; cost of cremation, 40c per ton.

Proposal C—Storage capacity 100 tons, one plant, $35,650; two plants, $68,400; cost of cremation, 30c per ton.

Proposal D—Storage capacity 120 tons, one plant, $41,080; two plants, $77,800; cost of cremation, 30c per ton.

Plants of 200-ton capacity:

Proposal E—Storage capacity 100 tons, $52,590; cost of cremation, 45c per ton.

Proposal F—Storage capacity, 120 tons, $61,680; cost of cremation, 35c per ton.

Proposal G—Storage capacity, 200 tons, $69,875; cost of cremation, 25c per ton.

The following bids for disposal plants being more or less irregular and not in accordance with specifications, were not read:

Decarie Manufacturing Co., Minneapolis, Minn.—One 200-ton plant, $81,750; two 100-ton plants, $85,000.

The bids were construed by me to be irregular in that they provided for the incineration of "combustible refuse and rubbish" as well as "garbage," a provision not in the advertisement.

Sanitary Engineering Co., New York City—One 200-ton plant, $75,000.

The bid was irregular in that the proposal was accompanied by a bond instead of a certified check as called for by the advertisement.

* * * * * * * * * * * * * *

The following bid of the Engle Crematory Co., of Des Moines, Ia., did not in any respect comply with the terms of the advertisement.

First. Offer to furnish the city the right to use the "Engle Fuel and Process for Making" for disposal of night soil, garbage and manure during life of the patent, the city to furnish and own the necessary machinery for

preparing the same for fuel and to pay the company as compensation therefor one-half of the net profits derived from the use of said fuel and process.

Second. Offer to furnish the right to use the company's crematory patents, the city to pay as compensation therefor for the services and expenses of a superintendent of construction to be designated by the company, whose services and expenses shall not exceed $10 per day.

A letter was also received from the American Exchange Co., of Providence, R. I., who recommended two 100-ton plants, and stated that the company's apparatus with license for life of the patent would not exceed $75,000 for each 100-ton plant. The machinery necessary to complete plant, piping, fittings, shafting, setting up of machinery and the erection of a building to contain the same would add to the cost of each plant not to exceed $80,000, making the estimated cost of each plant, exclusive of site, $155,000. Neither this proposition nor that of the Engle Crematory Co. were accompanied by any certified check.

In response to an advertisement inviting proposals for the disposal of garbage for terms of one, three, five and ten years, the following were received:

Detroit Sanitary Works, Detroit, Mich. —

One year contract	$24,600 per year
Three year contract	$14,600 per year
Five year contract	$13,600 per year
Ten year contract	$12,000 per year

Detroit Reduction Co., Detroit, Mich.

Ten year contract, no compensation.

If this proposal is accepted the company agrees if desired to dispose of all household and shop waste, office and

street sweepings and ashes, and all other rubbish, at 25c per ton; and if ashes is kept separate from above, for 20c per ton. Disposal of night soil, 25c per barrel. The company agrees to sell its plant to the city at an appraised valuation at any time prior to the termination of the contract.

Nearly all of the bids for disposal plants were accompanied by more or less elaborate blue prints and plans showing the character of the plant proposed to be erected.

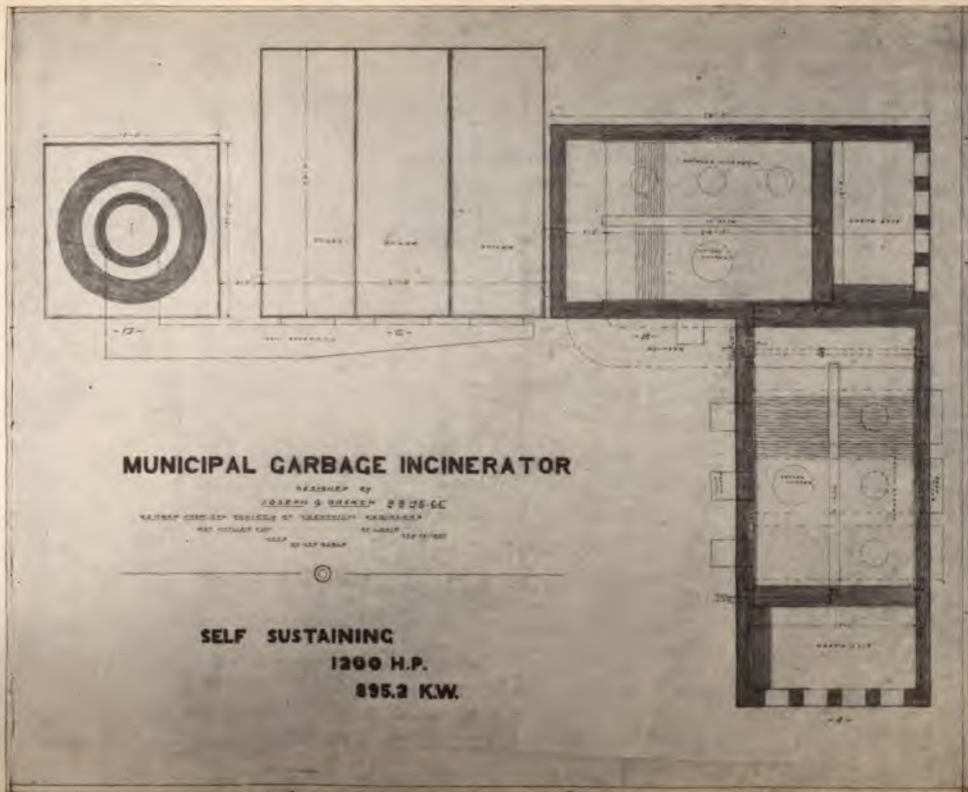
I recommend the reference of all of the above named bids, together with the plans and specifications therefor to the Committee on Health.

Respectfully,

F. A. BLADES,
Controller.

On Jan. 20, 1906, the Council confirmed the award of the contract to the Detroit Reduction Co. for the free disposal of the city garbage for a period of ten years from and after July 1, 1906.

It is reported that legal action will be taken to restrain further proceedings.



Transverse Section of the Branch Municipal Garbage Incinerator.
Fig. 1.

CHAPTER VI

THE BRANCH GARBAGE INCINERATOR.

(Patented Nov. 21, 1905.)

GENERAL DESCRIPTION.

(Figs. 1 and 2.)

The incinerator is composed of two separate units or furnaces, set at right angles to each other and so connected by a by-pass that either one or both can be fired, and the waste gases therefrom led under a battery of boilers before escaping into the stack.

The first furnace, or "A," is so connected with the second furnace, or "B," that the heat and gases therefrom are fed into the second furnace at a point immediately in the rear of the bridge wall, before passing into the boiler furnaces and out through stack.

This not only insures complete combustion and destruction of all offensive gases, but gives an even distribution of heat throughout the entire furnace, thus insuring the complete destruction of all garbage dumped into rear end of furnace, the same as nearer the fire.

The two furnaces "A" and "B" are provided each with two separate sets of grate bars, one immediately above the other. The garbage is dumped through hoppers upon hollow garbage supporting grates, which run transversely from side to side, being inclined downwardly.

These water grates are connected on the sides to two headers, and in the center to a single larger header. Through these headers and connecting water grates the feed water is pumped to the boilers, thereby securing a positive circulation, and preventing the grate bars from burning out. This also does away with the necessity of a feed water heater, delivering the feed water at boiling temperature to the boilers.

The advantage of having these grates downwardly inclined is to bring the garbage to the center of furnace, which is the hottest point, and at the same time prevent the clinkers from coming in contact with the sides of the highly heated furnace to which they will adhere.

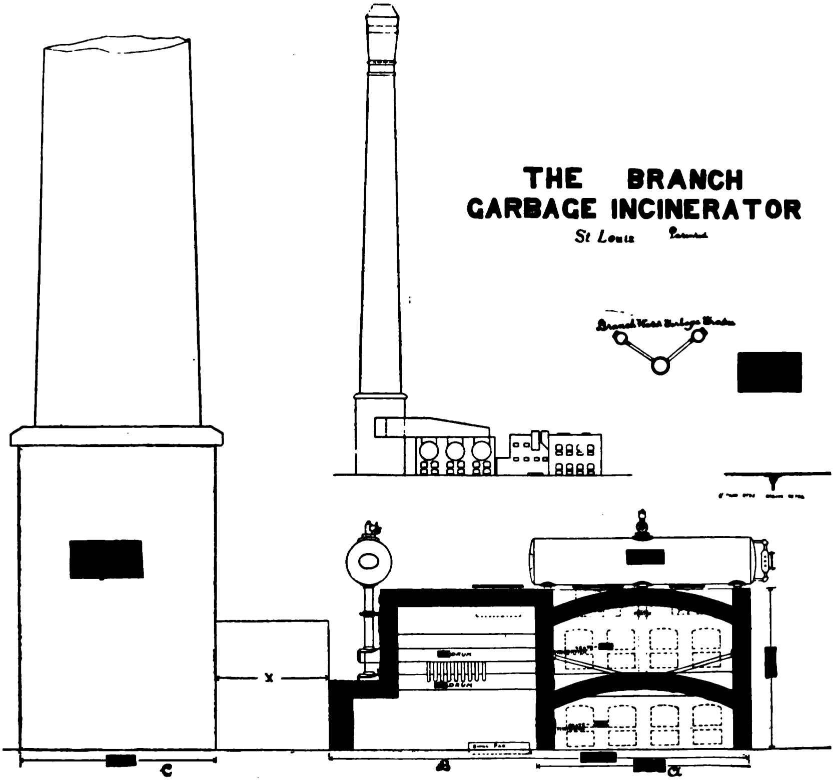
The two upper headers are connected in the rear of each furnace by a "T" from which connection is made direct to the boilers.

To the lower header the pump connection is made, into which the cold water from the city main, or other source of feed, is pumped.

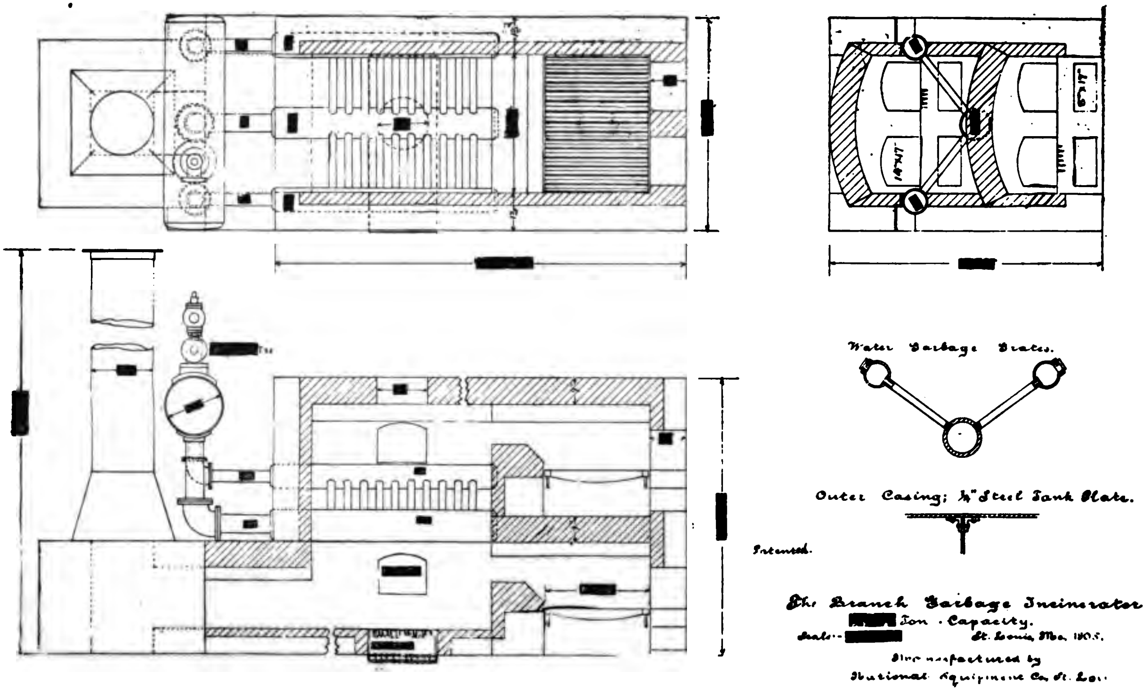
The water grates are expanded into the upper headers, having first been threaded into the lower or middle header, thus exposing only one threaded joint of each grate to the direct heat of the gases.

The fire grates are of the ordinary kind used for firing coal, all made interchangeable throughout. On the sides of the garbage furnaces are openings for stoking the garbage. In the ash pit under the lower garbage grates swill pans are inserted into which the liquid garbage thrown in the hopper above is run, and which is evaporated by the heat of the furnace itself, passing out with the other gases.

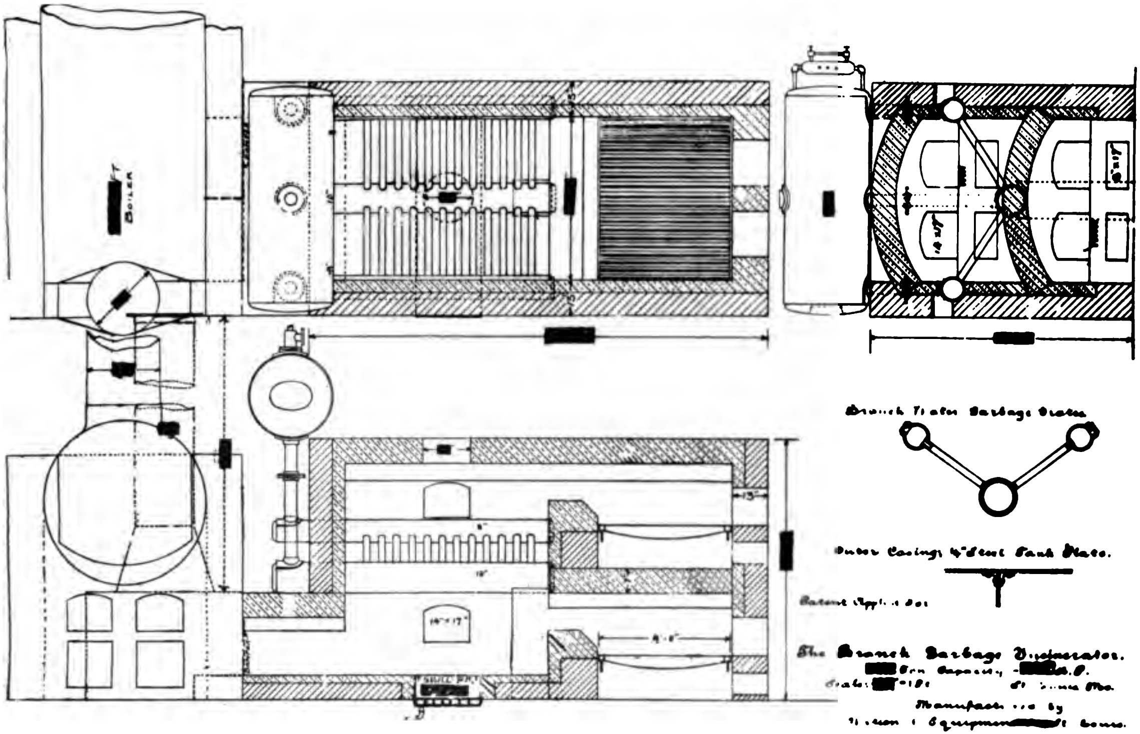
There is an offset, or break, in the rear of each furnace, thereby forcing the gases from the upper garbage grates



Side Elevation and Vertical Section of Branch Incinerator.



Horizontal and Vertical Sections of the Branch Garbage Incinerator, Without Boiler Attachment.
Fig. 3.



Horizontal and Vertical Sections of the Branch Incinerator, with Boiler Attachment.

Fig 4

to pass down into the lower furnace before passing out. By this means the unconsumed gases from the upper, cooler and shorter garbage furnace are forced down into the hotter and longer furnace below, where the two are mingled and entirely consumed before being discharged from the first furnace into the second, or from the second furnace into the boiler furnaces, thus insuring more perfect combustion and greatly aiding the draft. By introducing the heated gases immediately in rear of bridge walls, both the combustion and draft are greatly increased.

Either natural or mechanical draft can be used, though the latter is preferred, using steam jets for small plants.

The entire structure is enclosed in a tank steel casing, using angle irons as shown in small sketch on cut.

A platform extends over the furnaces on to which the garbage carts are driven, and the garbage dumped direct into the furnaces.

This incinerator can be built in single or double units, of any capacity desired, and insures the incineration of garbage of every character, including dead animals and night soil.

All parts are interchangeable and can be bought in the open market.

Any type of boiler can be used, the headers and water grates being similar to those used in the ordinary down draft furnaces.

The incinerator can be built with or without boiler attachment, as shown in Figs. 3 and 4.

PRINCIPAL ADVANTAGES CLAIMED.

No odor or dust, but complete sanitation.

No sorting or handling of garbage at plant.

No garbage dumped on the fire or on fire brick.

No auxiliary furnace or checker work necessary.

No fire brick or tile used for garbage grates, as the liquid garbage soon cracks the highly heated tiles.

No uneven distribution of heat in furnace.

Fewest number of threaded joints exposed to fire and heated gases.

No clinkers brought in contact with the highly heated walls of the furnace, to which they will adhere.

All garbage within sight and easy reach of stokers.

No water jackets or stay bolts used.

Complete and positive circulation through water grates, and ease of access to same at all times.

ALL WASTE HEAT UTILIZED FOR POWER OR HEATING PURPOSES.

Refuse consumed per square foot grate per hour, 67 lbs.

Water evaporated per pound of refuse from and at 212 degrees Fahr., 1.8 lbs., average temperature of feed water being 63.4 Fahr. I. H. P. per ton of garbage burnt in 24 hours, 8.

Coal consumed per ton of garbage, 90 lbs.

Average temperature of furnace, 1,800 degrees Fahr.

Lowest temperature, 1,500 degrees Fahr.

Average steam pressure, 115 lbs. per square inch.

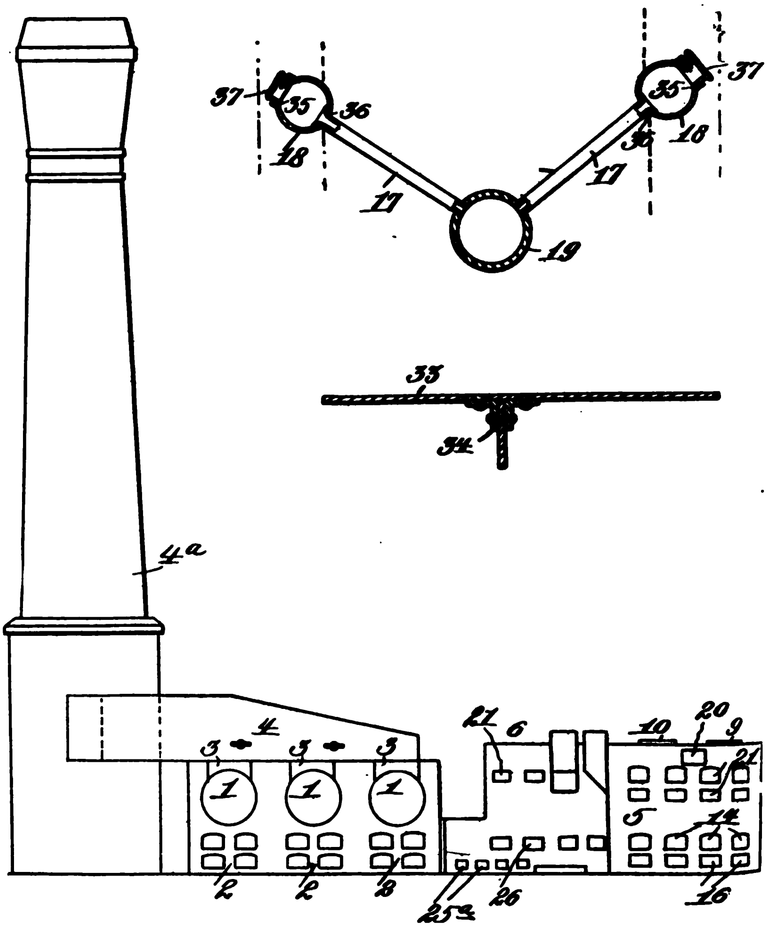
Forced draft pressure, 1.8 inches water.

Steam consumption of jets, 12 per cent.

DETAIL DESCRIPTION.

(Figs. 5, 6 and 7.)

The incinerating furnaces or crematories 5 and 6 are duplicate in construction and arrangement, and the furnace 5 is disposed in a plane at right angles to the furnace

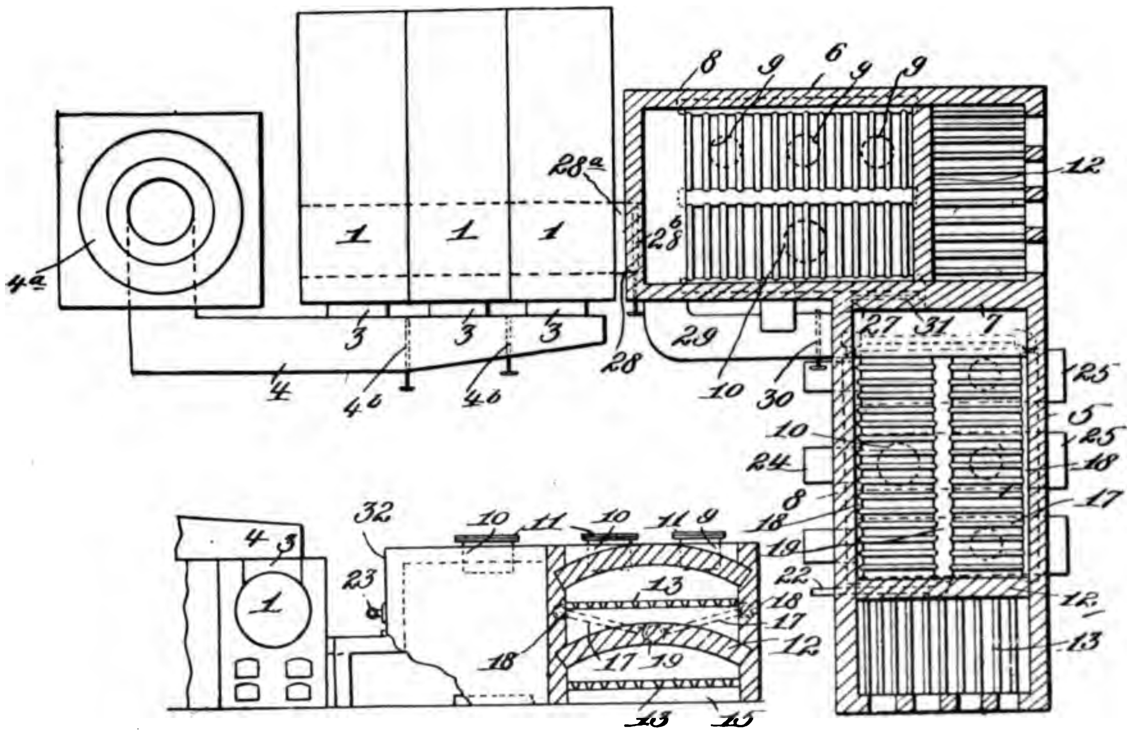


Detail Front Elevation of the Branch Garbage Incinerator.

Fig. 5.

Tank Steek Casing Enclosing Incinerator.

Fig. 6.



Detail Top Plow View of Branch Garbage Incinerator.

Fig. 7.

6, the rear extremity of the said furnace 5 being formed as a part of the side wall of the furnace 6, as at 7. Each furnace 5 and 6 has an inclosing wall 8 of suitable thickness and material and of sufficient strength to permit garbage and other vehicles or receptacles to be moved on or over the top thereof for dumping or deposit purposes. The top of each furnace at an intermediate point has garbage-receiving hoppers 9 adjacent to one side and at the opposite side a dead-animal-receiving hopper 10 of greater diameter, the several hoppers 9 and 10 being normally closed by tight-fitting caps or covers 11. In the front extremity of each furnace is a suitably-arched bridge wall 12, and below the plane of the same is a fire grate 13 of any preferred form and accessible by doors 14. Below the fire grate 13 the usual ash pit 15 is provided, and also rendered accessible by doors 16. Immediately in advance of the bridge wall 12 and at an elevation above the plane of the fire grate 13 is a garbage or refuse-receiving grate composed of a series of downwardly-inclined tubular members 17, connected at their outer ends to tubular headers 18, held in the side walls of the furnace, and at their inner ends to a depressed header 19, having a greater diameter than the headers 18. The tubular members or grate bars 17 and the headers 18 and 19 constitute a tubular grate, through which water circulates. The tubular garbage or refuse-receiving grate is disposed under the hoppers 9 and 10 and is accessible for cleaning purposes through the medium of a rear door 20. The tubular garbage or refuse-receiving grate can also be readily reached for cleaning and other purposes by a series of doors 21 in the rear end of the furnace. As clearly shown by Fig. 7, the

front extremities of the central and one side header are connected to a feed-water inlet 22, which may be attached to a city main or any other source of supply, and secured to the rear terminal of the remaining side header and its companion header at the opposite portion of the furnace is a feed-water outlet 23 adapted to be connected to the battery of boilers in any suitable manner to supply the said boilers with heated water and by this means dispensing with the necessity of a feed-water heater for the boilers. A suitable pump may be used for forcing the water into the boilers from the outlet connection 23. Each furnace also has a series of liquid-hoppers 24 at one side, which communicate at their lower terminals with removable swill-pans 25, disposed transversely under the garbage or refuse-receiving grate or resting on the bottom of the furnace. The swill or liquid which is deposited in the hoppers 24 and passes into the pans 25 is evaporated by the heat of the furnace itself, and the gases generated by such evaporation of the swill or liquid pass out with the remaining gases. It is also frequently necessary to stoke the garbage or refuse on the tubular grates, and for this purpose openings 26, having suitable covers, are formed in the sides of each furnace.

The fire-grates of the furnaces are of the ordinary type used for firing coal and all made interchangeable throughout. In the construction of the tubular grates, including the members 17 and the headers 18 and 19, the said tubular members are first threaded into the lower or central header 19 and then expanded into the upper side headers 18, thus exposing only two threaded joints to the direct heat of the gases. The advantage of having the tubular grates for receiving the garbage and other refuse downwardly inclined toward the center of the furnace is to

bring the garbage nearest to the greatest point of heat and at the same time prevent clinkers from coming in contact with the sides of the highly-heated furnace, to which under other conditions they would adhere.

As before noted, either one or both incinerating furnaces 5 and 6 may be operated, and when both furnaces are in use the gases and products of combustion pass from the rear of the furnace 5 through an opening 27 into the furnace 6 immediately in rear of the bridge-wall 12 of the latter and under the tubular garbage or refuse receiving grate of the said furnace 6. By this means the gases and products of combustion from the furnace 5 are more intensely heated and taken up in the furnace 6 and pass, with the gases from the latter, through an opening 28 into the adjacent furnace 2 under the first boiler 1 of the battery of boilers and circulate under the said battery of boilers for heating the water in the latter to produce steam and power and finally escape into the main conduit or breeching 4 and then pass into the stack 4a. Between the rear portion of the inner side of the furnace 5 and the rear extremity of the adjacent side of the furnace 6 is a by-pass conduit or flue 29, having a damper 30 near the wall of the furnace 5. The opening 27, forming communication between the rear of the furnace 5 and the furnace 6, is also provided with a suitable damper 31 at times to control the joint operation of the two incinerating furnaces. When the two incinerating furnaces are in operation, the damper 30 of the by-pass 29 is closed, thereby forcing the gas and products of combustion from the furnace 5 to pass into the furnace 6 directly in rear of the bridge-wall 12 of the latter furnace, as heretofore explained. If the furnace 5 alone is in operation, communication with the furnace 6

through the medium of the opening 27 is closed and the damper 30 opened, and under such arrangement the gases and products of combustion are liberated from the rear of the furnace 5 through the by-pass 29 and pass into the rear of the furnace 6 and then escape through the opening 28 into the adjacent furnace of the battery of boilers. The furnace 6 can be used alone without operating the furnace 5, and under these conditions the dampers 30 and 31 will be closed. When both furnaces are in operation, it will be obvious that the incinerating capacity of the plant is materially increased and the gases and products of combustion passing into the furnaces 2 of the battery of boilers 1 have a considerable volume, with increased effectiveness as a heating means for said battery of boilers. At the rear of each furnace, as clearly shown by Figs. 1 and 2, an offset or break 32 is provided which forces the gases from the upper garbage or refuse-receiving grates to pass down into the lower portion of the furnaces before escaping from the latter. By this means the unconsumed gases from the upper cooler and shorter furnace are forced down into the hotter and larger furnace below where all gases are mingled and entirely consumed before being discharged from the first furnace into the second or from the second furnace into the boiler-furnaces, thus insuring more perfect combustion and aiding the draft. Furthermore, by introducing the heated gases immediately in rear of the bridge-wall of the furnace 6 both the combustion and draft are greatly increased. This same point of introduction of the gases is also carried out with respect to the furnace 2 under the first boiler 1.

Either natural or mechanical draft is used in connection with the furnaces, it being preferred to employ mechanical draft established by the usual means or through

the medium of steam-jets. It is also preferable to have a platform structure over the top of the furnaces, onto which the garbage-carts are driven to permit the garbage to be directly dumped into the incinerating furnaces.

The entire incinerating structure, including both furnaces, is inclosed by a tank steel casing 33 (see Fig. 6), having the parts thereof connected by angle-irons 34.

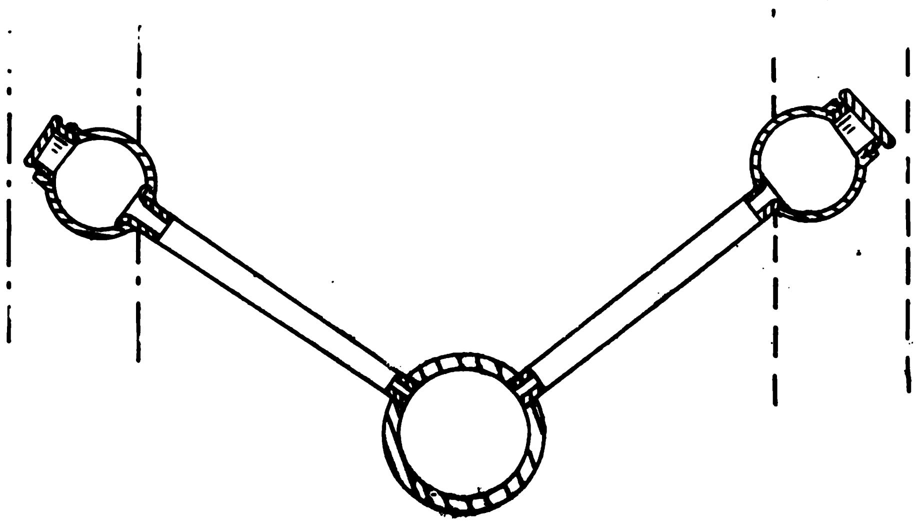
Ash-doors 25a are also provided on both sides of the incinerating furnaces in line with the swill-pans, as clearly shown by Fig. 6. The breeching 4 at regular intervals between the connections 3 are provided with dampers 4b to permit the use of one or more of the boilers 1, as may be desired. The opening 28 in the rear wall of the furnace is connected by a flue or conduit 28a with the boilers, said conduit continuing under the boilers, and through the furnaces of the latter, as indicated by dotted lines in Fig. 3, to deliver the products of combustion and gases from either one or both of the incinerating furnaces to the most advantageous points within the said boiler furnaces, and to entirely cut off the incinerating furnaces from the boiler furnaces or battery of boilers and permit the latter to be used independently of the said incinerating furnaces a damper 28b is suitably arranged in the opening 28 or in the flue 28a and exteriorly operative.

One of the most essential advantages in the operation just explained is complete combustion and destruction of all offensive gases with an even distribution of heat throughout the entire area of each of the furnaces 5 and 6, thus insuring the destruction of all garbage dumped into the rear end of each furnace as fully as the garbage deposited near the fire. Convenience in arrangement and economy in expense of installment are also material points in view of the fact that any type of boiler in the battery

of boilers may be used. The headers and water grates or members 17 are similar to those used in the ordinary down-draft furnaces, and the remaining elements can all be bought in the open market and do not require a specific construction to adapt them for use in the furnaces. No firebrick or tile is used in connection with the garbage-receiving grates, and the inconvenience resulting from the liquid or moist garbage contacting with highly-heated brick or tile is obviated.

As before described, the tubular members or grate-bars 17 are threaded into the intermediate or central enlarged header 19, and in applying the said tubular members or grate-bars they are inserted through openings 35 and 36 at diametrically opposite points in the outer headers 18, the upper ends of the said grate-bars being expanded into the lower openings 36 of said outer headers. The outer openings 35 have closing-nipples 37 and are of such diameter that the grate members 17 can be inserted therethrough and also through the openings 36, and after assemblage of the grate-bars in the manner set forth the nipples are applied to the said outer openings.

The most essential feature of this apparatus is the right-angular arrangement of the incinerating furnaces 5 and 6, and the advantage gained by such disposition of the furnaces is the increased length of travel given the heated gases, permitting the incinerating furnace 6, or second unit, to not only consume the unburned gases from the first furnace 5, but also to assist the draft and permit an easy firing of all the furnaces of both units. Another important advantage is the arrangement of the incinerating furnaces in operative relation to the battery of boilers and their furnaces for practical employment or utilization of



The Branch Water Grates.
Fig. 8.

the waste gases for steam-raising purposes, yet have the parts so constructed that the battery of boilers is used alone at times when the incinerating furnaces are not in operation. It has been found that no incinerating plant can be successful if it does not provide for a utilization of the waste gases and of the disposition of the incinerating furnaces in angular relation as specified, whereby waste gases are given a greater range of travel and cumulative in the second incinerating furnace or the latter nearest to the battery of boilers. Outer water jackets are also dispensed with, and the disadvantages incident to such jackets are overcome in the present incinerating furnace structure by non-use of such devices. The use of an auxiliary furnace is not required in the present structure, and consequently the expense in this direction is further avoided, as well as the unsatisfactory operation of auxiliary furnaces.

BRANCH WAGON WASHER AND DISINFECTOR.

(Patents Allowed.)

The object of this apparatus is to furnish an unlimited quantity of hot water, or water having a disinfectant combined therewith, which may be discharged at any desired pressure and temperature into the garbage wagons, whereby the same may be quickly and thoroughly cleaned, and if desired also disinfected. In order to accomplish this two tanks are used in conjunction with a boiler so that while the hot water is being discharged from one tank, the other tank is being filled with water and heated.

DETAIL DESCRIPTION.

(Fig. 9.)

Referring to the Fig. 9 (1) indicates a vertical boiler in which the steam used in the apparatus for heating purposes and for supplying pressure, is generated, (2) and (3) indicate respectively, two steel tanks for containing water, or water and the disinfectant to be employed, and (4) indicates a tank containing the disinfectant.

This apparatus as installed by the City of St. Louis, consists of one 40 h. p. vertical boiler, 48x120 inches, constructed by the Brownell Company of Dayton, Ohio, and two high-pressure steel tanks, 3 feet in diameter by 6 feet long, each of a capacity of 318 gallons. When burning 2 1-3 bushels of coal per hour, 2,500 gallons of water at 60 degrees can be heated to 150 degrees and discharged under 90-pounds steam pressure per square inch per hour. It was put in operation April 1, 1905, and has since been in continuous service, cleaning and disin-

View Showing Tanks and Connections of the Branch Garbage Wagon Washer and Disinfector.

Fig. 9.

The Branch Wagon Washer and Disinfector Used by the City of St. Louis.

fecting on an average of seventy-five wagons per day, and without costing one cent for repairs.

Fig. 10 shows this apparatus in operation.

Fig. 11 is a type of animal wagon used by that city.

The following letter from the former Street Commissioner sets out fully the capacity and merits of this apparatus.

CITY OF ST. LOUIS

Street Department,
Commissioner's Office.
May 31, 1905.

MR. JOS. G. BRANCH,
Chief Inspector, Boilers and Elevators,
City Hall.

MY DEAR SIR:—

The Garbage Wagon Washer and Disinfector designed by you for the use of this Department has been in operation since April 1st, 1905, and giving perfect satisfaction.

With the Washer we can heat 300 gallons of water to 200 degrees Fahrenheit in seven minutes, and by using the two tanks alternately we always have an abundant supply of water. It cleanses and disinfects the wagons perfectly, requiring about 30 seconds to a wagon.

Respectfully,
(Signed) CHAS. VARRELMANN,
Street Commissioner.

Animal Wagon Used by the City of St. Louis.
Fig. 11.

SPECIFICATIONS

(Figs. 3 and 4.)

Covering the Construction of the Branch Garbage Incinerator of 50 Tons Daily Capacity of 24 Hours.

Same to be built in accordance with the accompanying plan and following specifications:

GENERAL.

The drawings and explanations herewith submitted are to be considered as illustrations and parts of these specifications. General plans drawn to a scale of 1½ inches to the foot, and detailed drawings to a scale of 1 inch, ½ inch and 1-3 inch to the foot shall be furnished if desired.

GENERAL CONSTRUCTION.

The incinerator as shown upon drawings shall be of brick and steel construction, outside dimensions 8 feet by 7 feet 2 inches by 12 feet 6 inches, the outer shell of the incinerator being ¼-inch steel plates, securely held in place by angle-iron supports at the four corners, with angle-iron stiffeners around top and bottom of the shell, of the size and dimensions shown upon drawings. Longitudinal and traverse tie rods shall be used for the purpose of tieing brick walls and steel shell firmly together.

The upper garbage furnaces shall contain one central drum in each, which drum shall be 10 inches outside diameter, made of special lap-welded steel tubing with walls ½ inch thick, and tested to 150 lbs. per square inch hydrostatic pressure. The two lateral drums in each furnace shall be made of 8-inch extra heavy pipe, and also tested to 150 lbs. per square inch hydrostatic pres-

sure. The central drums shall be each equipped with one complete hand hole, with cover arch, bolt and gasket; the lateral drums shall each be fitted with one $3\frac{1}{2}$ by $5\frac{1}{2}$-inch hand hole, complete, with cover arch, bolt and gasket.

The incinerator shall be provided with one steel drum 7 feet by 30 inches, tested to 150 lbs. hydrostatic pressure, and fitted with one hand hole, complete. Each drum shall be further provided with proper water glass and gauge cocks.

The garbage water tube grates shall be made of 2-inch special cold drawn seamless steel tubing, spaced as shown on the drawings from which these specifications are made.

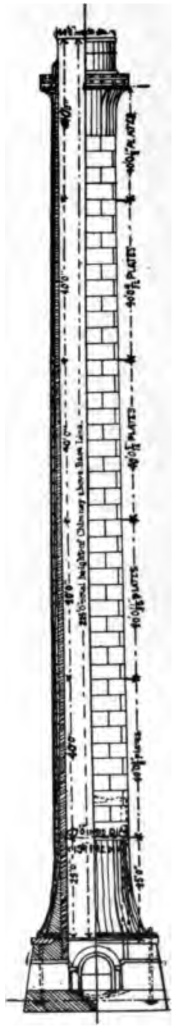
In the 8-inch drums, directly opposite each of the water tube grates, there shall be located an opening of sufficient size to allow the tube to pass through same, and be threaded into central drum and expanded into lateral drums.

These openings shall be provided with brass plugs of the proper dimensions. All drums and water grates shall be provided with all necessary connections, same to be of extra heavy pipe. The water inlet and outlet pipes shall be $2\frac{1}{2}$ inches, and the connections between the 8-inch drums shall be 2 inches. All fittings throughout shall be extra heavy, and all valves used be of the best standard make. The incinerator shall be provided with double firing furnaces, each furnace 5 feet wide by 6 feet long, and provided with standard double grate bars, 6 feet long, with the necessary front and back bearing bars for supporting same. The firing furnaces shall be provided with two cast iron fire doors, fitted with draught shutters and perforated liners. The firing doors

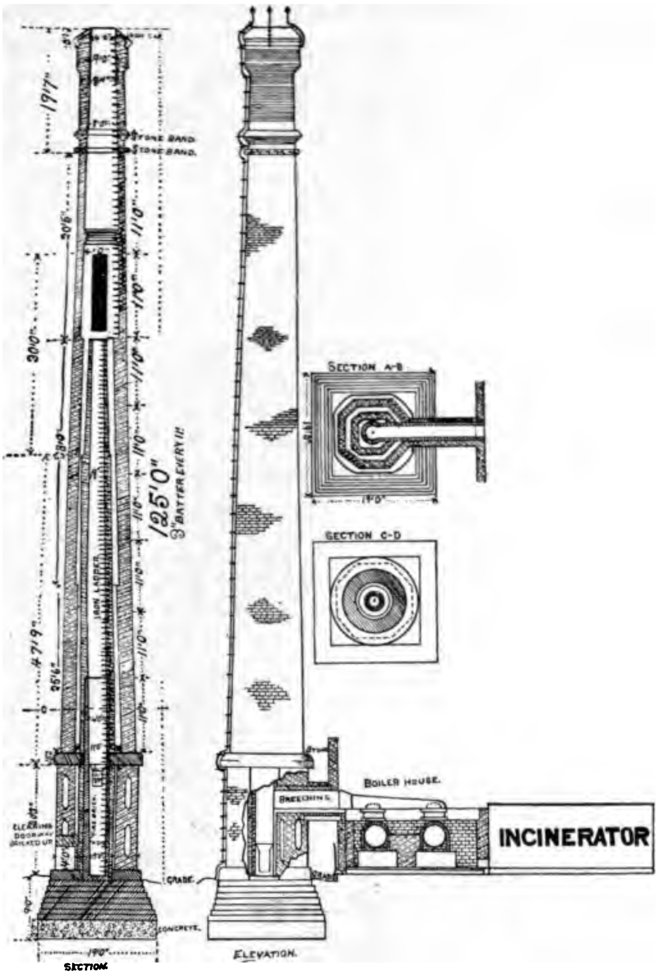
shall be attached to furnaces by means of cast iron frames, and each firing door shall be provided with a liner box 9 inches deep. The ash doors shall be made of 14-inch tank steel, properly hinged to furnace. The sides of the incinerator shall be provided with the proper number of cleaning-out doors, as shown in plans. On top of the incinerator, directly over the water tube grates, shall be located two garbage chutes 18 inches inside diameter, made of cast iron, and one animal chute 36 inches inside diameter, all made of cast iron, and all of which chutes shall be fitted with heavy cast iron covers provided with rings for lifting same. On either side of the incinerator, and in line with the circular openings for garbage and dead animals, shall be located one side hopper for liquid garbage, fitted with sliding valves held in place with angle-iron guides, and fitted with counter-weights and wire cables for opening and closing same.

In the bottom of the side hoppers shall be placed 3-16-inch steel perforated drain plates; these drain plates to allow the discharge of all liquids from the garbage to be conducted directly to the evaporating pan through vertical drain pipes, which connect with flanges on the bottom of the hoppers as shown. These drain pipes pass through the shell of the furnace at points indicated on drawings, and shall discharge all liquids as before mentioned, directly into the evaporating pan.

This evaporating pan, which is located beneath the lower garbage furnace, shall be constructed of 5-16-inch steel plates with a 4-inch live steam space properly stayed to withstand a steam pressure of 150 lbs. to the square inch. Outside dimensions being 24 inches by 17 inches. A live steam connection from the steam and water space to the evaporating pan shall be made of 1½-inch piping, fitted



225-foot Stack, Iron Lined with Brick. 200-ton Incinerator.
Fig. 12.



125-foot Stack Dimensions for 50–100-ton Incinerator.
Fig. 13.

with necessary valves for opening same. This evaporating pan shall also answer the purpose, and shall be used, as an ashpan, receiving the ashes which pass through the cast iron lower grates. At the under side of the evaporating pan a connection shall be taken from the live steam space, and by suitable piping the condensation from the evaporating pan shall be led to a steam trap, and from there discharged into a hot well.

At the front end of the firing furnace, and securely fastened to the shell of same, shall be a combustion chute for waste paper, boxes, etc., fitted with suitable cast iron valve. The valve shall be constructed and operated in the same manner as those in the side hoppers. This combustion chute shall be constructed of ¼-inch steel plates, firmly riveted to corner angles, as shown, and extending from the front end of the furnace to the line of unloading floor, where it shall be fitted with heavy angle-iron stiffeners, and also provided with wrought iron handles for opening and closing same. There shall be NO WATER JACKETS OR STAY BOLTS USED THROUGHOUT THE ENTIRE CONSTRUCTION, EXCEPT FOR THE EVAPORATING PANS AS ABOVE SET OUT. NO THREADED JOINTS SHALL BE EXPOSED TO THE FIRE, OR HEATED GASES, OTHER THAN ABOVE SET OUT.

FIRE DOORS AND STOKING DOORS.

At the sides of the incinerating furnaces shall be located suitable firing and stoking doors. The upper, or stoking doors, shall give free access to the "V"-shaped grates, and admit of the free stoking of the material. The lower, or fire doors, open directly to the lower grates. These garbage fire doors and stoking doors shall be fitted

with wrought iron latches, so arranged as to guard against any possibility of doors being opened other than when necessary for stoking, and other purposes.

Proper ash doors shall permit of easy access to the evaporating pan located as above set out.

INTERIOR FIRE BRICK AND FIRE TILE LINING.

The interior walls of the incinerator shall be of the best quality of fire brick and tile. Suitable steel or wrought iron anchors shall be used for securely holding the brick and tile in place. No part of the walls shall be less than 13 inches in thickness, and same shall be built in strict accordance with plans and drawings attached.

SMOKE STACK.

(Fig. 13.)

The smoke stack shall be of brick construction, 125 feet in height and 4 feet in diameter, and constructed as shown in detailed blue print herewith submitted. There shall be a steel ladder constructed and attached to the stack, running the full length from roof to top of stack.

DUST CATCHER.

There shall be a dust catcher chamber, constructed according to the plans accompanying these specifications.

MECHANICAL DRAFT.

The incinerator shall be equipped with steam jets under each firing furnace, which jets shall not consume more than 12% of all steam generated at a boiler pressure of 110 lbs. to the square inch, and which jets shall give an ashpit pressure of at least 1½ inches.

POWER OR HEAT.

The incinerator shall be provided with proper by-pass connections, fire-brick lined, of the dimensions shown on the drawings, so as to permit of the utilization of all the waste heat therefrom for boiler power or heating, should it at any time be desired to so utilize such heat.

The average temperature of the garbage furnaces shall be at least 1,500 degrees Fahrenheit, when the same are charged to their full capacity, and the waste heat therefrom shall show an evaporation of at least one pound of water from and at 212 degrees Fahrenheit, for each pound of refuse burned.

For larger size incinerators steel stacks lined with fire brick are much less costly than brick stacks and give good service.

Fig. 12 shows a steel stack for a 200-ton incinerator, for which the following are proper specifications, viz.:

The smoke stack shall be of steel construction 225 feet in height, the first 50 feet to be 7 feet in diameter, and the balance to be 6 feet in diameter, and of the weight and construction as shown in detailed drawings of stack, and fully described in separate stack specifications. Stack shall be properly held in place by suitable bands and guy wires fastened to anchors as shown upon drawings. There shall be also a steel ladder constructed and attached to the stack, running the full length from the roof to the top of the stack. Stack shall also be lined with circular fire brick for the first 50 feet from the base.

HEIGHT OF CHIMNEYS.

Area Square Feet.	Diameter, Inches.	75	80	85	90	95	100	110	120	130	140	150	175	200
		Heights in Feet. Commercial Horse Power.												
3.14	24	75	78	81	...	...	...	...	....	....	....	....	....	....
3.69	26	90	92	95	98	...	...	...	....	....	....	....	....	....
4.28	28	...	106	110	114	117	120	...	....	....	....	....	....	....
4.91	30	...	122	127	130	133	137	...	....	....	....	....	....	....
5.59	32	...	...	144	149	152	156	164	....	....	....	....	....	....
6.31	34	...	...	162	168	171	176	185	....	....	....	....	....	....
7.07	36	...	...	...	188	192	198	208	215	....	....	....	....	....
8.73	40	...	...	...	...	237	244	257	267	279	....	....	....	....
10.56	44	...	...	...	...	287	296	310	322	337	....	....	....	....
12.57	48	...	...	...	...	...	352	370	384	400	413	....	....	....
15.90	54	...	...	...	...	...	445	468	484	507	526	....	....	....
19.63	60	...	...	...	...	...	...	577	600	627	650	672	....	....
23.76	66	...	...	...	...	...	...	697	725	758	784	815	....	....
28.27	72	...	...	...	...	...	...	...	862	902	932	969	1044	....
38.48	84	...	...	...	...	...	...	...	1173	1229	1270	1319	1422	....
50.27	96	...	...	...	...	...	...	...	....	1584	1660	1725	1859	1983
63.62	108	...	...	...	...	...	...	...	....	2058	2102	2181	2352	2511
78.54	120	...	...	...	...	...	...	...	....	....	2596	2693	2904	3100

The following heights are recommended for chimneys, with the coals mentioned: 75 feet for free burning bituminous coal, 100 feet for slow-burning bituminous slack, 115 feet for slow-burning bituminous coal, 125 feet for anthracite pea coal, 150 feet for anthracite buckwheat coal. With such coal as Mt. Olive, a 150-foot stack is recommended. With plants operating 600 or more horse-power of boilers, 180 feet is the minimum height, irrespective of the kind of coal that is to be burned. For large plants a 200-foot stack is not excessive.

WEIGHTS OF IRON STACKS; WITH GAUGES AND PRICES.

Diam. Inches	Height in Feet.													
	1	20	25	30	35	40	45	50	55	60	65	70	80	90	100
10	7.5	150	188	225	263	300	338	376	414	450	488	526	600	676	750
12	8.5	170	213	255	298	340	383	426	469	510	553	596	680	766	850
14	10.5	210	263	315	368	420	473	526	579	630	683	736	840	946	1050
16	12.5	250	313	375	438	500	563	626	689	750	813	876	1000	1126	1250
18	14.	280	350	420	490	560	630	700	770	840	910	980	1120	1260	1400
20	15.	300	375	450	525	600	675	750	825	900	975	1050	1200	1350	1500
22	16.5	339	413	495	578	660	743	826	909	990	1073	1156	1320	1486	1650
24	18.	360	450	540	650	720	810	900	990	1080	1170	1300	1440	1620	1800
26	37.5	750	938	1125	1313	1500	1688	1875	2063	2250	2438	2626	3000	3376	3750
28	41.	820	1025	1230	1435	1640	1845	2050	2255	2460	2665	2870	3280	3690	4100
30	44.	880	1100	1320	1540	1760	1980	2200	2420	2640	2860	3080	3520	3960	4400
32	46.5	930	1163	1395	1628	1860	2093	2326	2559	2790	3023	3256	3720	4186	4650
34	49.5	990	1238	1485	1733	1980	2228	2476	2724	2970	3218	3466	3960	4456	4950
36	52.5	1050	1313	1575	1837	2100	2362	2616	2877	3150	3412	3674	4200	4724	5250
38	55.	1100	1375	1650	1925	2200	2475	2750	3025	3300	3575	3850	4400	4950	5500
40	58.5	1170	1443	1755	2044	2340	2629	2886	3175	3510	3799	4088	4680	5258	5850
42	61.	1220	1525	1830	2135	2440	2745	3050	3355	3660	3965	4270	4880	5490	6100
48	69.5	1390	1738	2085	2433	2780	3128	3476	3824	4170	4518	4866	5560	6256	6950
54	78.5	1570	1963	2355	2748	3140	3533	3926	4319	4710	5103	5496	6280	7066	7850
60	87.5	1750	2188	2625	3063	3500	3938	4376	4814	5250	5688	6126	7000	7876	8750

The gauge and price are determined by the diameter of the stack. For a stack 10 inches to 18 inches in diameter, use a No. 18 gauge iron, which will cost about 5 cents per lb. From 18 inches to 40 inches diameter, use 18-inch, 16-inch and 14-inch gauge; which will cost 5 cents per lb., and for larger diameters, use 10-inch and 12-inch gauge, costing for No. 12 gauge 3½ cents and No. 10 gauge 3¼ cents per lb.

CHAPTER VII.

STEAM AND HOT-WATER HEATING.

No branch of engineering has made as rapid strides in the last few years as sanitary engineering.

The steam and hot-air furnace, with their expense, dirt and inconveniences, have given way to steam and hot-water systems of heating, affording a luxury to the rich and poor alike which was formerly unknown.

The various systems of heating by steam may be classed: (1) high-pressure systems; (2) low-pressure systems; (3) vacuum or exhaust systems.

Under the class of high-pressure systems are all systems that require for heating a greater boiler pressure than 15 pounds per square inch; in the second class are those that operate between 15 pounds boiler pressure and the atmospheric pressure, while in the third class are all systems that work at a lower pressure than the atmosphere; that is, require a partial vacuum for their successful operation. Each of these systems in turn may be subdivided into: (1) the one-pipe system; (2) the two-pipe system; (3) the two-pipe system, with separate return risers; (4) the overhead main, or drop-supply system.

These subdivisions are further subdivided into gravity return systems and forced return systems.

In the *gravity return system* the condensation flows back to the boiler by gravity. To operate this system it is therefore necessary that the full boiler pressure be

carried on the entire heating system, which is unsafe and impractical, and it therefore is not much in use.

In the *forced return system* the condensation is forced back into the boiler from the return mains of the system by the use of a pump, steam trap or steam loop. To operate this system a reducing valve is necessary, which valve is placed on the steam supply pipe to the system. This system is most generally used, having the avdantage of both safety and economy.

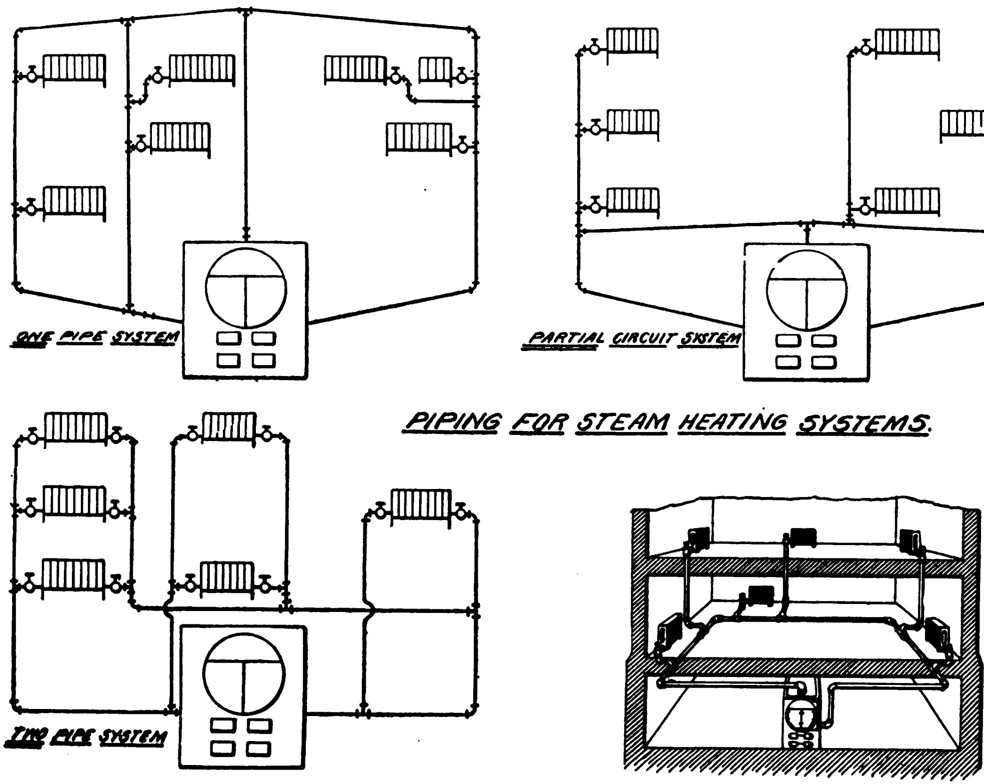
The main difference therefore between steam-heating systems, is the method of returning the condensation to the boiler.

ONE-PIPE SYSTEM.

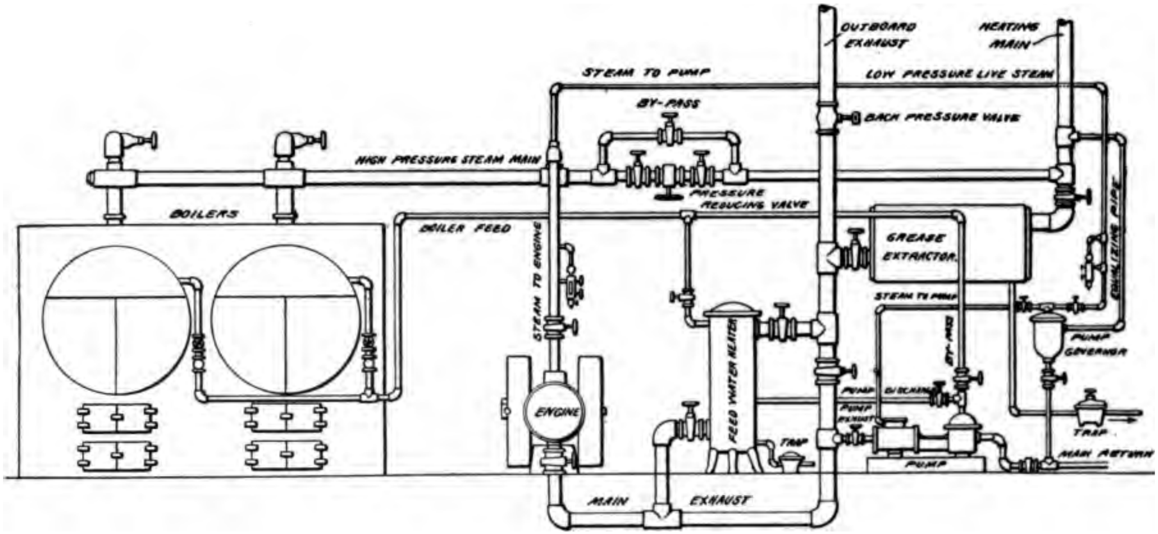
This system, as shown in Fig. 14, is the simplest form of heating systems, and the system now universally used, when the building or the space to be heated is not too large. The steam from the boiler is carried to the risers through one pipe, the condensation flowing back through the same pipes, thereby causing the steam and condensation to move in opposite directions, which is a disadvantage, as the steam becoming wet, may cause a water "hammer." With proper installation, and by keeping all valves wide open, this can be avoided.

TWO-PIPE SYSTEM.

This system, as shown in Fig. 14, has two connections for each radiator, one serving as an inlet for the steam and the other as an outlet for the water of condensation, the steam passing through one pipe and the water flowing back to the boiler through the return pipes. In this system the steam and water are carefully separated, and the



One-Pipe and Two-Pipe Systems.
Fig. 14.



BACK PRESSURE SYSTEM

Fig. 15.

circulation is therefore much better in this system than in the one-pipe system. The principal objection to it is its first cost.

THE SEPARATE-RETURN SYSTEM.

The only difference in this system from the ordinary two-pipe system is that each radiator is provided with its own separate return pipe.

THE DROP-PIPE SYSTEM.

In this system the steam supply passes through a riser direct from the boiler to the highest point of the system. The radiators are connected to the steam supply pipe with single pipes, the same as in the one-pipe system, but in this system the steam and condensation move in the same direction.

EXHAUST OR BACK-PRESSURE SYSTEM.

This system, as shown in Fig. 15, is a low-pressure system, having the great economical advantage of permitting of the utilization of the exhaust steam from engines and pumps, which would otherwise go to waste. The steam-heating main is connected to the exhaust pipe from the engine or pump, also to a live steam pipe from the boiler. This live steam when used is made to pass through a pressure reducing valve, which reduces the pressure to the amount required for the heating system. Should the supply of exhaust steam become excessive, the excess will escape by the opening of the back pressure valve and its discharge into the atmosphere. When the engines or pumps are stopped the steam in the heating system is prevented from passing backwards and

filling the same with water by the use of a check valve. The relief valve is set to blow off at a pressure of about one or two pounds higher than that maintained by the reducing valve. The safety of the system depends on the proper working of this relief valve.

As exhaust steam at five pounds gauge pressure contains 971 B. T. U., the merit of this system can at once be seen.

This system is in universal use for heating large office buildings and entire business districts where access can be had to steam power plants.

THE VACUUM SYSTEM.

This system differs from the exhaust system just described in that its operation causes no additional back pressure on the engine or pump, but removes at least a part of the back pressure from same, as a vacuum is constantly maintained on the returns. This farther permits this system to be operated either as a high or low pressure system, and to secure its steam supply from any source, either as exhaust or live steam.

Generally the system is operated with exhaust steam, a two-pipe system being used. The returns are connected to a receiver, which collects the air and water in the system. To this receiver is connected a vacuum pump, which removes all the air and water in the system, and maintains a vacuum at any desired degree. This pump only removes the air and water from the system, which are discharged into an open tank, permitting the air to escape, and the water remaining is pumped back into the boiler, using an ordinary feed pump for this purpose.

The thermostatic valves which are placed on the return end of each radiator to open automatically when water or air passes, are made to close when steam begins to pass.

With this system steam can be used at a temperature as low as 140 deg. F., and at the same time the capacity of the engine to do work is increased. As the temperature of the steam used in this system is lower than in other systems, the radiators must be proportionately larger.

The Webster vacuum system, which is shown in Fig. 16, is one of the best vacuum systems on the market.

HOT-WATER HEATING.

Hot-water systems are very similar to the steam systems described, except that hot water flows through the pipes and radiators, instead of steam. The hot-water system has the great advantage, though, of the ease of regulation of the temperature. With a steam system, it is necessary to regulate the temperature by turning on or off the steam entirely, which causes either too high or too low a temperature, unless operated carefully.

With a hot-water system the radiators can be kept turned on at all times, the regulation of temperature being secured by varying the temperature of the water flowing through them. There are two distinct hot-water systems of circulation employed, one depending on the difference in temperature of the water in the outlet and return pipes, called *gravity circulation*, and the other called the *forced circulation* system, in which a pump is employed to force the water through the mains. The first, or "gravity circulation" system, is used for dwellings and buildings, and the latter system for large buildings, and wherever there

are a long run of mains. For the first system usually a sectional cast iron boiler is employed, although any type of boiler may be employed. In the second or "forced circulation" system, a heater to warm the water, and a centrifugal or rotary pump is used. Fig. 17 is type of a sectional cast iron boiler.

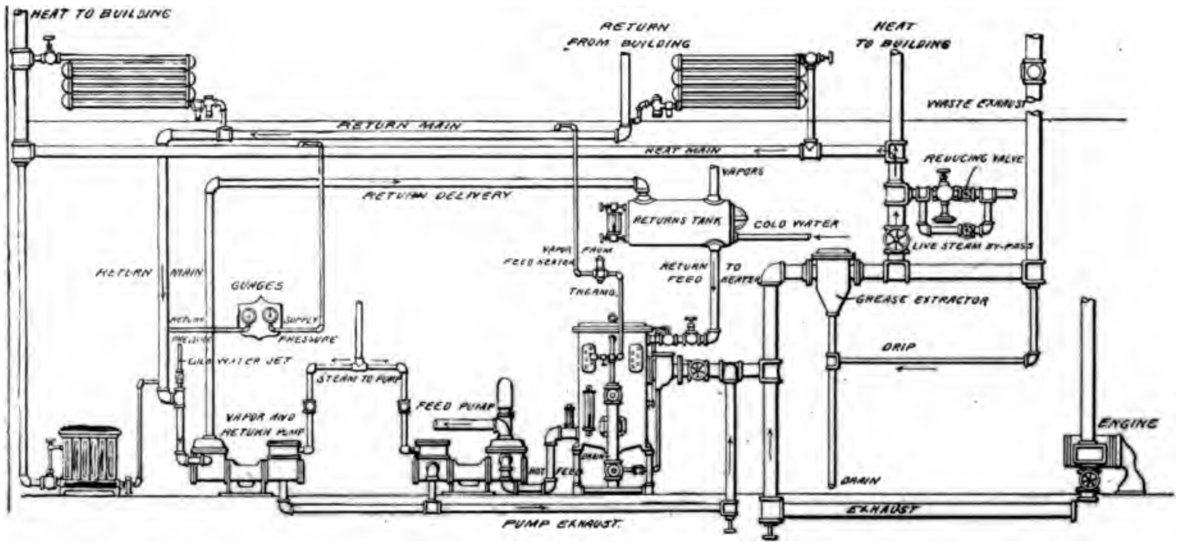
A system for hot-water heating costs more to install than a steam-heating system, owing to the difference in the expense of the radiators, and the larger piping that is required but is more economical.

INDIRECT HOT-WATER SYSTEM.

In this system the air to be heated is taken from a cold air box in connection with the space beneath the heater. This air in passing through the spaces between the sections of the heater, and becoming warmer, rises to the rooms above through registers placed in the floors or walls, as most convenient.

FORCED-BLAST HEATING.

This system of heating is used for the warming of factories, schools, churches, or any large building where good ventilation is also desired. The air to be used for warming is either drawn or forced through a heater of special design by a fan or blower and discharged into ducts which lead to registers placed in the halls to be heated. By means of a by-pass damper, so placed that only part of the air will pass through the heater and part around and over it, the proportions of cold and heated air may be so adjusted as to give the desired temperature to the air entering the halls.



WEBSTER VACUUM SYSTEM.

Fig. 16.

Sectional Boiler for Steam Heating.
Fig. 17.

COST OF OPERATION OF THE COLONIAL SECURITY PLANT.

An Office Building in St. Louis.

William Toevs, Engineer.

Dr.

Coal 260 tons at $1.84 per ton	$478.40
Wages for engine room	315.00
Washing boilers on Sunday	10.00
Packing, oils and waste	25.00
Repairs	25.00
Hauling ashes	35.00
Total	$888.40

Cr.

Heat and steam sold	$471.00
Electric lights, 13,795 K. W. at 3c per Killo hour.	413.85

HEAT FOR BUILDING.

734,400 cu, ft. of air, for which is required 12,240 sq. ft. radiation, at 10c per sq. ft. $204.00

ELEVATORS FOR BUILDING.

30 h. p. per day of 10 hours, 80 lbs. water per h. p. hour	2,400 lbs.
10 h. p. for 6 hours at night, 80 lbs, water per h. p. hour	4,800 "
Total lbs. water used per day	28,800 "
Per month of 26 days	748,800 "
10 h. p. for 48 hours on Sundays	38,400 "
Total water used for elevators	787,200 lbs.

COAL CONSUMED.

Evaporation 1 lb. of coal to 5 lbs. of water, 787,200 lbs. water divided by 5, equals 157,440 lbs of coal burned, or 73 tons at \$1.84 per ton equals \$134.32. Adding 35% loss from friction pumping 12,000 to 14,000 gals. of water for building daily, \$46.90. Total, \$181.20.

6 h. p. for 12 hours at 100 lbs. per hour, or 7,200 lbs. per day, or 21,600 per month; 21,600 lbs. water requires 43,200 lbs. of coal, costing...	\$28.64
Cost for heating 6,000 gals. daily, raising temperature from 60 to 140 degrees, requiring 1 lb. of coal for each 2 gals. of water, or 3,000 lbs. coal daily, or 90,000 lbs. monthly, cost..	\$82.80

Income	\$1,380.40
Expense	888.40
Cr. to building	\$492.00

The wages for one of the engine room employes should be charged to house expense, being \$60.00 per month, for electric work, plumbing and care of radiators.

CHAPTER VIII.

INCINERATORS COMBINED WITH CENTRAL HEATING PLANTS.

The success of incineration depends upon the utilization of the waste heat from the furnaces, and the success of central heating plants depend upon their ability to obtain heat for their requirements at a much less cost than now paid for coal, or the exhaust steam from neighboring power plants.

Therefore the two are to a great extent mutually dependent upon each other, and especially is this true as to the heating plant, for the waste heat from incineration can be utilized for electric lighting, water works, sewerage, or other power purposes.

Of the 190 central heating plants at present in operation in this country, there is not a half-dozen of such plants making a dividend, which is due alone to the necessity of supplementing the exhaust steam with coal, and this applies alike to both hot-water and steam-heating systems. With coal at $2.00 per ton and exhaust steam at 3½ cents per 1000 pounds, no heating plant can be operated at a profit when charging the usual price of 18 cents per square foot for radiation, unless the plant can obtain a sufficient supply of exhaust steam to do their *entire* work, with the system well loaded.

As it is usually impossible to get such a supply of exhaust steam from neighboring power plants, except when

the system is very small, it becomes necessary to use a good grade of coal for the additional heat required, which makes it only a question of time before the plant will go into the hands of a receiver. While central heating plants have proved almost without exception financial failures, they have given universal satisfaction to their patrons, and the extent of their business has been limited only by the heating company's refusal to make further extensions, or accept more business. In many cities the service has been so satisfactory that the patrons have volunteered to assist in increasing the rates permitted by the ordinance under which the company obtained its franchise, while others seeking to obtain its service, have advanced to the company the necessary amount to have it installed in their residences. There can be no question as to the popularity and the general demand for central heating at reasonable rates. The present difficulty is to so reduce the expense of operation of the plant so as to permit of such rates. This can be done only by obtaining waste heat in large quantities at a small cost. The heat from coal is too expensive, for there is just so many heat units in coal, varying with the grade of the coal, and the number of these heat units can neither be increased nor diminished by any means in our power, and the price, therefore, necessary to charge for same in order to operate the plant with a profit, makes its service in most instances prohibitive to the general public. The heat units in exhaust steam can be obtained at a must less cost, as they have assisted in performing work before being allowed to escape as waste from the exhaust of an engine or pump. These heat units are not again available for power, but retain their value for heating purposes, and it is on them the present heating plants must rely for their success.

But such supply is necessarily limited. The waste heat from an incinerator is ample and the cost low enough to make it almost priceless in value to heating companies.

As the heat from one ton of refuse in incineration will develop 8 H. P., at a cost of 19 cents, or 2.4 cents per H. P., and as one H. P. will supply from 150 to 200 square feet of radiation, which can be sold at least for 18 cents per square foot, the profit which therefore can be derived from the combination of an incinerator with a central heating plant, is amply sufficient to enable heating companies to give satisfaction not only to their patrons, but also to their stockholders.

In order for heating plants to utilize this waste heat, it is only necessary that they install their boilers between the incinerator and the chimney, and the waste heat to be properly conducted under same before being allowed to escape. This, of course, means that the heating plant, with its pumps, and necessary machinery, must be installed within close proximity to the incinerating plant, but this is no objection; on the contrary, it is an advantage, for the same labor can then operate both plants at a considerable saving. Should the city operate the incinerating plant, then the waste heat can be purchased outright by a company paying an agreed price per boiler H. P. developed; or, for the steam generated per 1000 lbs., using a steam or condensation meter for measuring same.

As incinerating plants must be operated continuously night and day the entire year, for at least seven months in the year it makes this heat especially adaptable for heating purposes. During those months when no heat is required by the heating company, the heating system can be thoroughly overhauled and made ready for the next season's work. During this period the waste heat

in part can be utilized for the works purposes and the balance either sold for other purposes, or allowed to go to waste, for there certainly should be sufficient profit made during the heating season alone to satisfy any company.

RADIATORS.

Fig. 19 shows the general form of a radiator for direct heating which is similar for steam and hot water, the one difference being that the sections are connected at the top, as well as the bottom, for hot water, but connected only at the bottom for steam. A cap is used to close the ends of the top connection, and by this the difference in the two radiators can be seen at a glance. Radiators for *indirect heating* differ in construction so as to permit the cold air to be heated, to be freely drawn or forced around or through them.

RADIATION SURFACE.

The following will show the proportionate radiation surface to the cubical contents of the room to be warmed, where direct radiation is used:

Bathrooms and living-rooms with three exposed walls and a large amount of glass surface require an allowance of 1 square foot for each 40 cubic feet.

Bathrooms and living-rooms with two exposed walls and a large amount of glass surface require an allowance of 1 square foot for each 50 cubic feet.

Bathrooms and living-rooms with one exposed wall and an ordinary amount of glass surface require an allowance of 1 square foot for each 60 cubic feet.

Sleeping rooms require an allowance of 1 square foot for each 60 to 70 cubic feet.

Halls require an allowance of 1 square foot for each 50 to 70 cubic feet.

School rooms require an allowance of 1 square foot for each 60 to 80 cubic feet.

Churches and auditoriums having large cubical contents and high ceilings require an allowance of 1 square foot for each 65 to 100 cubic feet.

Lofts, workshops and factories require an allowance of 1 square foot for each 75 to 150 cubic feet.

SIZES AND CAPACITY OF THE BRANCH STEAM TRAPS.

	No. 0	No. 1	No. 2	No. 3	No. 4
Height over all........	48 in.	38 in.	27 in.	18 in.	12 in.
Size of pipe connection	2½ in.	1½ in.	1¼ in.	1 in.	½ in.
Weight	800 lbs.	300 lbs.	130 lbs.	90 lbs.	30 lbs.
Lineal ft. 1-inch pipe trap will drain.......	60,000	27,000	13,500	6,000	2,300
Capacity in sq. ft. of radiation	22,000	8,500	4,800	2,000	850
Capacity in lbs. water per hour	7,100	3,000	1,800	725	225

The Branch Steam Trap.
Fig. 18.

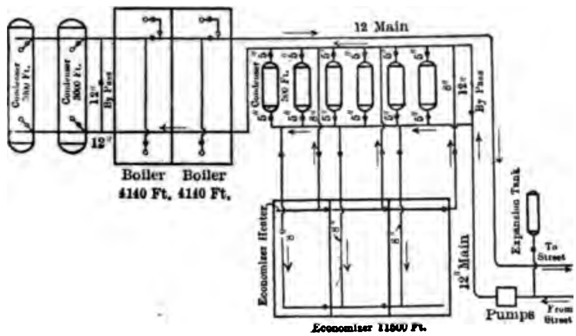
For indirect radiators allow at least 50 per cent more surface.

As no heating system can be successfully operated without steam traps of sufficient capacity to remove all the condensation, opposite is given the proper sizes and capacities of traps for this class of work.

CENTRAL STATION HEATING.

Where large districts are to be heated, a central heating station becomes necessary, the steam or hot-water mains from same being laid underground through the streets. Both steam and hot water are used for this character of heating, but it is generally admitted that where the district is large that the hot-water systems are the best, as there is much less loss from condensation in the mains, and the temperature can be much better regulated. As the exhaust steam from some large plants is generally used in connection with either of these systems, the central heating plant should be located as near as possible to it, and the exhaust steam conveyed through an underground duct in as direct a path as possible. The equipment of the station depends largely upon the extent of the district to be heated, it being usual to allow for steam heating 1 square foot of boiler heating surface for supplying 10 square feet of radiating surface, or one boiler horse power to each 120 to 200 square feet of radiating surface, depending upon whether steam or hot water is used.

Radiator for Steam Heating.
Fig. 19.



Contract Station Heating Plant.

Fig. 20.

COMMERCIAL CENTRAL HEATING STATIONS IN PLACES OF 3,000 POPULATION AND UPWARDS, WITH REPORTS ON OPERATION OF SAME.

(The Municipal Year Book.)

City or Town.	Population.	Owner.	Ind. or Comb.
Laconia, N. H,...	8,042	Belknap El. Power Co........	Independent.
Springfield, Mass.	62,059	Springfield Gas Lt. Co........	Gas Wks.
Pawtucket, R. I...	39,231	Pawtucket El. Co.............	El. Lts. & Ry.
New Haven, Conn.	108,027	New Haven Ht. Sup. Co......	Independent.
Auburn, N. Y.....	30,345	Auburn El. Co................	El. Lts.
Dunkirk, N. Y....	11,616	A. W. Cummings.............	Independent.
Fredonia, N. Y....	4,127	Dunkirk & Fredonia R. R. Co..	El. Lt. & Rys.
Hornellsville, N. Y.	11,918	American Ill. Co..............	El. Lts.
Geneva, N. Y.....	10,433	Geneva Steam Heating Co....	Independent.
Lockport, N. Y....	16,581	Economy Lt., Ht. & Pr. Co....	Lt. & Pr.
Newark, N. Y.....	4,578	Newark Lt., Ht. & Pr. Co....	El. Lts.
Newburgh, N. Y..	24,943	Newburgh Lt., Ht. & Pr. Co..	El. Lts.
New York City...	3,437,202	New York Steam Co..........	Independent.
N.Tonawanda,N.Y.	9,069	The Fidelity Co..............	Independent.
Penn Yan, N. Y...	4,650	Penn Yan Heating Co........	Independent.
Allentown, Pa....	35,416	Allentown Ht. & Pr. Co......	Independent.
Bellefonte, Pa....	4,216	Bellefonte Gas Wks..........	Gas Wks.
Bloomsburg, Pa...	6,170	Bloomsburg St., Ht. & El.Lt.Co.	El. Lts.
Clearfield, Pa.....	5,081	Clearfield Steam Heating Co..	Independent.
Erie, Pa..........	52,733	Home Htg. Co................	Independent.
Greenville, Pa....	4,814	Peoples El. Lt., Ht. & Pr. Co.	El. Lt. Gas Wks.
Harrisburg, Pa...	50,167	Harrisburg St., Ht. & Pr. Co.	Independent.
Hazelton, Pa......	14,230	Hazelton Steam Co...........	Independent.
Johnstown, Pa....	35,936	Citizen Lt., Ht. & Pr. Co.....	El. Lts.
Lebanon, Pa......	17,628	Lebanon Steam Htg. Co.......	Independent.
Lock Haven, Pa..	7,210	Ill. Power & Heat Co.........	Independent.
Mahoney City, Pa.	13,504	Charles D. Kaier Co..........	Independent.
Mt. Pleasant, Pa..	4,745	Peoples' Htg. Co.............	Independent.
Phillipsburg, Pa...	3,266	Phillipsburg Steam Htg. Co...	Independent.
Philadelphia, Pa..	1,293,697		Independent.
Pottsville, Pa.....	15,710	Pottsville St., Ht. & Pr. Co...	Independent.
Reading, Pa......	78,961	Reading St. Ht. & Pr. Co......	Independent.
Scranton, Pa.....	102,260	Economy Ht., Lt. & Pr. Co....	Independent.
Shenandoah, Pa...	20,321	Shenandoah Ht. & Pr. Co....	Independent.

:OMMERCIAL CENTRAL HEATING STATIONS—(Continued).

?own.	Population.	Owner.	Ind. or Comb.
., Pa.....	4,663	Towanda El. Ill. Co..........	El. Lts.
ton, Pa...	7,670	Washington El. Lt. & Pr. Co..	El. Lts.
3arre, Pa.	51,721	Wilkes Barre Ht., Lt. & Pr. Co.	Independent.
urg, Pa..	11,866	Pennsylvania Ht & Pr. Co....	Independent.
ι.........	33,708	York Haven Traction Co......	El. Ry.
and, Md..	17,128	Edison El. Ill. Co.............	El. Lts.
Ga.......	89,872	Atlanta Ry. & Pr. Co.........	El. Ry.
s, O......	125,560	Indianola Land & Pr. Co......	Independent.
n, O....	6,473	Merchants El. Lt. & Pr. Co...	Gas Wks. El. Lts.
;, O......	7,940	Delaware El. Lt. & Pr. Co....	El. Lts.
....	10,989	Edison El. Lt. & Pr. Co......	El. Lts.
O........	131,822	Yaryan Htg. & Ltg Co........	El. Lts.
't, O......	6,422		
ton, C. H.	5,751	Washingt'n-Smead Ht. Watr Co	Independent.
wn, O...	44,885	Youngstown St. Heating Co...	Independent.
Ind......	6,115	Heat, Lt. & Pr. Co...........	El. Lt. El. Ry.
;ton, Ind..	6,460	Peoples Lt. Ht. & Pr. Co......	El. Lt. Gas Wks.
olis, Ind..	169,164	Home Htg. & Ltg. Co........	Independent.
, Ind.....	7,113	La Porte El. Co..............	El. Lts.
Ind.......	17,337		
Ind......	20,942	Muncie El. Lt. Co............	El. Lts.
ı, Ind....	3,118		
Ind......	6,041		
ute, Ind.	36,6?3	Terre Haute El. Co...........	El. Lts., El. Ry.
s, Ind...	10,249	John Hartigan Co.............	Independent.
pids, Mich.	87,565	Edison El. Lt. Co............	El. Lts.
ı, Mich..	3,259	Peninsula El. Lt. & Pr. Co...	El. Lts.
Mich....	16,485	A. A. & F. B. Piatt..........	El. Lts.
s........	14,210	Alton Ry. El. Lt. Co. & Gas...	Gas Wks. El. Lts.
:, Ills....	6,937	Belvidere Heating Co.........	El. Lts.
:ton, Ill..	23,286	City Dist. Heating Co.........	Independent.
;n, Ill....	9,098	Champaign & Urbana Gas & El. Ry. Co.	Gas Wks. El. Lts.
n, Ill....	5,488	Charleston Lt., Ht & Pr. Co..	El. Lts.
Ill......	16,354	Danville Gas, El. Lt. & St. Ry.	Gas Wks.E.L.,Ry.
Ill.......	20,754		
Ill.......	5,904	DeKalk El. Co................	El. Lts.

COMMERCIAL CENTRAL HEATING STATIONS—(Continued).

City or Town.	Population.	Owner.	Ind. or Comb.
Evanston, Ill......	19,259	Evanston Yaryan Co..........	El. Lts.
Jerseyville, Ill....	3,517	Jerseyville Lt., Ht. & Pr. Co..	El. Lts.
La Salle, Ill.......	10,446	Marquette Ht. & Pr. Co......	El. Lts.
Mattoon, Ill......	9,622	Mattoon Lt., Ht. & Pr. Co....	El. Lts.
Paris, Ill.........	6,105	Paris Gas., Lt. & Coke Co....	Gas Wks. El. Lts.
Paxton, Ill........	3,036	Electric Lt. Plant.............	El. Lts.
Pontiac, Ill.......	4,266	Pontiac El. Co................	El. Lts.
Quincy, Ill........	36,252	J. C. Hubinger...............	Independent.
Springfield, Ill....	34,159	Utilities Co. El. Lt. & Pr. Co..	El. Lts.
Sycamore, Ill.....	3,653	E. Hall	El. Lts.
Taylorville, Ill....	4,248	Taylorville El. Co............	El. Lts.
Urbana, Ill.......	5,728	Urbana Lt., Ht. & Pr. Co.....	El. Lts.
Janesville, Wis...	13,185	Janesville El. Co.............	El. Lts.
Kenosha, Wis.....	11,606	Kenosha Gas. & El. Co........	Gas Wks. El. Lts.
La Crosse, Wis....	28,895	La Crosse Gas & El. Co......	El. Lts.
Marinette, Wis...	16,195	Marinette Gas, El. Lt. & St. Ry.	Gas, El. Lts. S. R.
Boone, Ia.........	8,860	John Reynolds Co.............	
Burlington, Ia....	23,201	Burlington Ry. & Lt. Co......	El. Lts. Ry. Gas.
Cedar Rapids, Ia..	25,656	Cedar Rapids El. Lt. & Pr. Co.	El. Lts.
Davenport, Ia.....	35,254	Davenport Gas & El. Co......	Gas Wks. El. Lts
Des Moines, Ia...	62,139	Des Moines St. Htg. Co......	Independent.
Grinnell, Ia.......	3,860	Carney & Hammond..........	El. Lts.
Marion, Ia........	4,102	Marion Lt., Ht. & Pr. Co......	El. Lts.
Mason City, Ia....	6,746	Brice Gas & El. Co...........	Gas Wks. El. L
Missouri Valley, Ia	4,010		
Muscatine, Ia.....	14,073	Muscatine El. Ry. Co.........	Gas El. Lts. R
Ottumwa, Ia......	18,197	Ottumwa E. & St. Co.........	El. Lts. Ry.
Perry, Ia.........	3,986	Perry El. Lt. & Pr. Co........	El. Lts. Ry.
Red Oak, Ia......	4,355	Red Oak El. Co..............	El. Lts.
Webster City, Ia..	4,613	Municipal Plant..............	El. Lts., W. W
Albert Lea, Minn.	4,500	Albert Lea Lt. & Pr. Co......	El. Lts.
Crookston, Minn..	5,359	Crookston W. Wks., Pr.& Lt.Co.	W. Wks., El. L
Owatonna, Minn..	5,561	Owatonna Gas, El. & Htg. Co.	El. Lts.
St. Cloud, Minn..	8,663	St. Cloud W., Lt. & Pr. Co....	El. Lts.
St. Paul, Minn..	163,065	Manhattan Lt., Ht. & Pr. Co..	El. Lts.
Fort Scott, Kan..	10,332	Fort Scott Consol. Sup. Co....	El. Lts., Ry.
Topeka, Kan.....	33,608	Edison Illum. Co.............	El. Lts.

COMMERCIAL CENTRAL HEATING STATIONS—(Continued).

City or Town.	Population.	Owner.	Ind. or Comb.
Bismarck, N. Dak.	3,319	Hughes El. Co.	El. Lts.
Grd Forks, N.Dak.	7,652	Grand Forks Gas & El. Co.	Gas Wks., El. Lts.
Butte, Mont.	30,470	Phoenix El. Co.	El. Lts.
Kansas City, Mo.	163,752	Kansas City El. Lt. Co.	El. Lts.
St. Joseph, Mo.	102,979	St. Joseph Ry. Lt., Ht. & Pr.Co.	El. Lts., Ry.
Sedalia, Mo.	15,231	Economy St. Htg. & El. Co.	Independent (?)
Waxahachie, Tex.	4,215	Waxahachie El. Lt. Co.	El. Lts.
Colorado Spgs.Colo	21,085	Colo. El. Co.	El. Lts.
Denver, Colo.	133,859	Denver St. Htg. Co.	Independent.
Seattle, Wash.	80,671	Seattle Pr. & Ht. Co.	Independent.
Salt Lake City,Utah	53,531	Utah Lt. & Pr. Co.	El. Lts.
Boise, Idaho	5,957	Artesian Hot & Cold Water Co.	Water Works.

ALBERT LEA, MINN. Population, 4,500

The Albert Lea Light & Power Co. are operating a central heating system in connection with their central station. They use the Evans, Almirall Co.'s hot water system, and it is giving practically no trouble, being operated nine months out of the twelve. They charge 17½c per square foot of radiation. They are giving satisfaction to their patrons. Single pipe system.

ALTON, ILL. Population, 14,210

The Electric Street Railway Co. operate a central heating system which furnishes heat for certain portions of the city.

The service is reported to be only fairly satisfactory, owing to the mains being in need of constant repairs.

ALLENTOWN, PA. Population, 35,416

The central heating plant in this city is reported to have never been a success, due it is claimed to its original

faulty construction, and the defective installation of the mains.

The pipes were merely encased in wood, without other insulation. The failure of this heating system is one of the many due to such defective insulation, and demonstrates the necessity of proper insulation of all mains, both for economy and satisfactory service. Without such insulation, the system necessarily must be a failure.

AUBURN, N. Y. Population, 30,345

Auburn Lt. Ht. & Pr. Co. operate a central heating plant, under a franchise granted by the city. They use live steam from 10 to 20 lbs. pressure, using steam traps which discharge into the sewers.

They have about 200 customers and furnish heat only in business portions of the city. This company has been in existence a number of years, but is reported never to have been a financial success, not making over expenses and repairs.

ATLANTA, GA. Population, 89,872

The Georgia Railway & Elec. Co. operate a central heating plant; which furnishes heat to the office buildings and main business districts of the city. This plant is operated in connection with their street railway and electric lighting plant.

The service is entirely satisfactory.

BURLINGTON, IOWA. Population, 23,201

The Peoples Gas & Elec. Co. are operating a central heating plant in this city.

BISMARCK, N. D. Population, 4,500

The Hughes Elec. Co. furnish heat for the N. Pacific Depot and Northwest Hotel.

BLOOMINGTON, IND. Population, 6,460

The Peoples' Gas, Electric & Heating Co. have been operating for the past five years a central heating hot-water system installed by the Schott Specialty Co., having a capacity of 125,000 square feet of radiation. The plant is fully loaded, and the company is preparing to extend the street mains during this year.

A rate of 15 cents per square foot radiation is charged, which is admitted to be too low, although the company has been enabled by the operation of their heating plant, in connection with their gas and electric plants, to earn a small dividend.

The service given their patrons is entirely satisfactory.

BOISE CITY, IDAHO. Population, 5,957

A private corporation operates a natural artesian hot water system, heating a number of the residences and business houses of this city.

BUTTE, MONT. Population, 30,470

The Phoenix Electric Co. are operating a small heating system in conjunction with their electric lighting plant. They heat about twenty buildings, with 45,000 square feet of radiation, for which they receive 60c per square foot for the entire year, 24 hours to the day, and every day in the year when temperature is below 65 degrees. They carry from five to ten pounds pressure,

using slack coal at $4.50 per ton in bins. The engineers work in three shifts of eight hours each, two receiving $4 per day, and fireman $3.50. They furnish some steam at 25-lbs. pressure, for cooking and heating water, for which they receive 60c per 1,000 lbs., measuring the condensation with meter.

BOONE, IOWA. Population, 8,800

The L. W. Reynolds Estate operate a heating plant in this city. For the first year or two the plant did not give satisfaction, but for the last two years the service has been entirely satisfactory.

CEDAR RAPIDS, IOWA. Population, 25,656

The C. R. & Iowa City Ry. and Lt. Co. operate a central heating station in this city, which is a success, both in its service and financial operation.

BOROUGH OF CLEARFIELD, PA. Population, 5,081

The Clearfield Steam Heating Co. operate a central heating station in this city, which is giving excellent satisfaction both in the public building and in private residences.

COLORADO SPRINGS, COLO. Population, 21,085

The Colorado Springs Electric Co. operate a heating plant in a limited way, supplying steam heat to buildings, being approximately 5,000,000 cubic feet. They have used both live steam and exhaust, and are at present using the latter.

The system is entirely satisfactory. They base their rates at 50c per 1,000 lbs. of steam condensed, and use condensation meters.

CHAMPAIGN, ILL. Population, 9,098

The U. & C. Ry., Gas & Electric Co. have been operating a central heating plant in this city since 1901, and furnishing heat to most all business houses in the city. The system does not extend out of the business district, except in a few instances.

The service has been entirely satisfactory.

DAVENPORT, IOWA. Population, 35,254

The American District Co. have been operating a central heating system for about five years, with entire satisfaction to its patrons and is reported to be also a financial success.

DEKALB, ILLS. Population, 5,904

The DeKalb-Sycamore Electric Co. operate a central heating system which was installed by the Consolidated Engineering Company. The company has 30,000 square feet of radiation in successful opration, for which they receive 35 cents per square foot.

DANVILLE, ILL. Population, 16,354

The Danville Street Railway & Light Co. operate a central heating system, using steam heat, which is reported to have been fairly successful. They charge the following rates for the heating season:

Residence rates—	Per 1,000 cubic feet
Frame houses, less than 20,000 cubic feet contents.	$6.00
Frame houses, more than 20,000 cubic feet contents.	5.75
Brick houses, less than 20,000 cubic feet contents.	5.50
Brick houses, more than 20,000 cubic feet contents.	5.25
Business house rates—	
Front rooms only, on upper floors...............	5.00
Any room, side, back and front exposure, less than 70 feet deep..............................	4.00
Any room, side, back and front exposure, more than 70 feet deep..............................	3.75
Rooms, back and front exposure, less than 70 feet deep	3.50
Rooms, back and front exposure, more than 70 feet deep	3.00
Any building, more than 150,000 cubic feet contents	2.50

The above rates are about the average rates charged throughout the country for steam heating. Where exhaust steam can be used *entirely*, with these rates a heating system can be made a profitable investment, but if it becomes necessary to supplement same with *live* steam, it then becomes a question of proper insulation.

DUNKIRK, N. Y. Population, 11,616

A. W. Cummings is operating a central heating plant in this city, furnishing steam heat to the public buildings, post office, business houses and schools. It is satisfactory in every respect. Rates for service, 40c per 1,000 lbs.

DENVER, COLO. Population, 133,859

The Denver City Steam Heating Co. are operating a central heating plant in this city, which is entirely satisfactory.

ERIE, PA. Population, 52,733

The Erie Co. have been operating a central heating plant in this city for the past six years, and its operation is entirely satisfactory.

EVANSTON, ILL. Population, 19,259

The Yaryan Co. installed a central heating plant in this city, but it is now owned and operated by the North Shore Electric Co. The service is liked very much, the only objection reported being the price charged.

FORT SCOTT, KAN. Population, 10,322

Mr. Grant Hornaday is president of the Gas & Electric Co., which company operates the only heating plant in this city.

BOROUGH OF GREENVILLE, PA. Population, 2,800

A private corporation has been operating a central heating plant in this city several years, and its service is very satisfactory.

The live steam from the Electric Light Plant is used to operate the same.

Mains are not more than ½ mile in length.

HORNELLSVILLE, N. Y. Population, 11,918

The American Illuminating Co. are running a central steam heating plant in connection with their electric light plant. It has been in operation seven years and heats more than 100 of the largest buildings, using exhaust steam, together with live steam. The company has about two

miles of line, consisting of 10-inch, 8-inch, 6-inch, 5-inch and 4-inch mains. The loss in the lines is slight. The service is very satisfactory to all.

HARRISBURG, PA. Population, 50,167

The Harrisburg Steam Heat & Power Co. operate a central heating station, which is very successful, and covers quite an extent of territory.

JANESVILLE, WIS. Population, 13,185

The Janesville Electric Co. heat several buildings in this city, near and adjoining their own, and are giving good satisfaction.

JERSEYVILLE, ILL. Population, 3,800

Plant was installed last year by a private corporation and is operated in connection with the electric lighting plant and water works. Is financially successful, and giving satisfaction to its patrons.

JOHNSTOWN, PA. Population, 35,936

The Citizens' Light, Heat & Power Co. operate a central heating system known as the Holly system, which was installed by the American District Steam Co. Exhaust steam is used, which is supplemented with live steam. They carry five pounds on their mains at the plant, and two pounds at their most distant point, which is one-half of a mile from the plant. The system is giving satisfaction to its patrons.

This company considers the central heating system a financial success, provided the rates charged are in propor-

tion to the cost and when most of the business can be taken care of by exhaust steam.

KANSAS CITY, MO. Population, 163,752

The Metropolitan Street Railway Co. are now installing a central heating system. There is a general desire for its service, as it will supply a great need.

KENOSHA, WIS. Population, 11,606

The Kenosha Gas & Electric Co. are operating a central heating station. It was one of the first plants installed in that part of the country. It is giving satisfaction to patrons, and is financially successful.

LEBANON, PA. Population, 17,628

The Lebanon Steam Co. have been operating a steam heating plant in this place since 1888. Is very satisfactory as to heat, but is reported not a success financially, owing to the rate charged being too low, and the patrons being much scattered over the city.

LITTLE ROCK, ARK. Population 60,000

The Litle Rock Heating Company operate a central heating plant, using the Schott hot-water system. This plant was installed in 1904 at a cost of $206,864, and while it has not proved a financial success, it has given entire satisfaction to its patrons. The company is now being operated by a Receiver.

The net cost of the plant was as follows:—

Site	$ 3,000.00
Materials	110,006.30

Pay Rolls	38,771.20
Interest and Discount	7,822.52
Management	9,274.30
Supervision	4,425.00
Engineer's Fees	12,500.00
Expenses of Engineer and Assistants	1,750.00
Freight	4,385.51
Drayage	3,504.57
Office and Ground Rents	480.00
Miscellaneous Expenses	945.10
Cash, Little Rock Heating Co.	10,000.00
Total	$206,864.50

The company has 175,000 feet of radiation in operation, and contracts offered for about 100,000 feet more, had it been in a position to suply the demand. The prices charged are 17c per square foot for radiation, and for hot water, $1.00 per thousand gallons.

The company uses the exhaust steam from the Little Rock Railway and Electric Company, paying 3.85 cents per 1,000 pounds of steam received, which is supplemented by coal.

The estimated income for the heating year 1905-6 is as follows:—

175,000 feet of radiation, at 18c.	$31,500.00	
1,500,000 gals. hot water, at $1.	1,500.00	
Profit on installing 50,000 feet of radiation	6,250.00	—$39,250.00

Estimated cost of operating plant during season of 1905-06:—

Exhaust steam	$ 2,100.00	
5,000 tons slack, at $2	10,000.00	
Superintendence, 7 months	875.00	
2 Engineers, 7 months	945.00	
4 Firemen, 5 months	1,000.00	
Oil and waste	200.00	
Water	350.00	
Electric lights	175.00	
Office rent	300.00	
Office man	720.00	
Printing, stamps and stationery	300.00	
Trouble man, 7 months at $75	525.00	
Taxes and insurance	800.00	
Maintenance	750.00	
Interest on bonds	12,500.00	—$31,540.00

Income	$39,250.00
Operating expenses	31,540.00
Net income	$7,710.00

LANSING, MICH. Population, 16,485

The Piatt Heating & Power Co. own and control the central heating plant and also furnish electric power for the Street Railway Co. This company has only lately been granted a franchise for general heating purposes, though it has been heating the state capitol and several large buildings near their plant for some time, with entire satisfaction. The company is now extending its mains so as to include residence heating throughout the city.

LOCKPORT, N. Y. Population, 16,581

The Economy Light & Fuel Co. are operating about six miles of mains from a central heating plant and giving perfect satisfaction to their patrons, which include several hundred residences, business houses and public buildings. Price is based upon meter rates. The operation of this plant has reduced to a great extent the smoke nuisance, also the fire risk.

MARINETTE, WIS. Population, 16,195

The Watson Heating Co. own and operate the central heating plant in this city. While it is giving satisfaction to its patrons, it is reported not a financial success.

MUSCATINE, IOWA. Population, 14,073

The central heating station at this place is not now being operated, nor has it been in operation for some time.

It is reported not to have been a financial success, but the service was satisfactory.

NEW HAVEN, CONN. Population, 108,027

The New Haven Heat Supply Co. operate a central heating system, more or less limited to the central business section of the city. They do a successful business, and there is general satisfaction among their patrons.

NEW YORK CITY. Population, 3,437,202

New York has no central heating station in the main sections, but there are several in the outlying districts, owned and operated by private corporations.

NEWBURGH, N. Y. Population, 24,943

Newburgh Light, Heat & Power Co. operate a central heating system in connection with the lighting business of the company, and supply a considerable portion of the city with steam heat. The system is very popular and gives entire satisfaction. It is contemplated extending the system so as to take in several streets not now piped.

OTTUMWA, IOWA. Population, 18,197

The Ottumwa Traction & Light Co. operate a central heating system in this city, using their exhaust steam for this purpose, which plant it is stated is not giving complete satisfaction to its patrons, but is a financial success.

OSKALOOSA, IOWA. Population, 9,212

The Oskaloosa Traction & Light Co. operate a central heating system in this city. It is a two-pipe hot water system, and giving satisfaction to its patrons, and is reported also financially successful.

PHILADELPHIA, PA. Population, 1,293,697

There are one or two heating stations in the suburbs of the city. None in the central districts.

PAXTON, ILL. Population, 4,200

The electric light plant put in central hot water heating plant five years ago, which system is being used by most of the business houses, private residences, some schools and churches.

A great number of the residences desire the service, but owing to lack of capacity they cannot be supplied. An extension of the system is contemplated.

PAWTUCKET, R. I. Population, 39,231

There is a central heating plant at this place.

PENN YAN, N. Y. Population, 39,231

The Penn Yan Steam Heating Co. are operating a heating system at this place.

PITTSBURG, PA. Population, 321,616

The Penn Heat & Power Co. operate a central heating plant, supplying both business and residence houses. Its patrons are well satisfied.

POTTSVILLE, PA. Population, 15,710

The Pottsville Steam Heat & Power Co. operate a central heating system in this city, using steam from a central generating plant. The season extends eight months, being from October 1st to June 1st. The plant was installed in 1888, and consists of six horizontal return flue boilers, each 72 inches in diameter and 18 feet in length, developing about 800 horse-power.

The fuel used is small-sized anthracite coal, known as "rice" and "buckwheat," which averages about $1.25 per ton delivered. Natural draft is used. A steam pressure of 60 lbs. square inch is carried, which is reduced to 15 lbs. minimum and 30 lbs. maximum pressure, according to weather temperature. The obstacles to overcome are leaks at expansion joints, about every 50 feet; loss by radiation from mains and laterals; also destruction of same by corrosion and the waste electrical current from trolley rails. The price made to their patrons is not any higher than would be the cost of the operation of in-

dividual house plants, considering the constant and abundant supply of heat, as well as the convenience and avoidance of dust from ashes and coal and the ease of regulation of temperature. The service has been entirely satisfactory to their patrons, and the plant is reported also a financial success.

READING, PA. Population, 78,961

The Reading Steam Heat & Power Co. have been operating a central station heating plant eighteen years. The service furnished is very satisfactory to its patrons, but is reported financially not to be a success.

ST. CLOUD, MINN. Population, 8,663

It is reported that the central heating plant was not a success financially, and it is not now in operation.

SCRANTON, PA. Population, 102,026

The Economy Light, Heat & Power Co. operate a central heating plant, furnishing heat to the city institutions, fire engine houses, etc., and also to public buildings, residences, etc. The rate is $4.50 per 1,000 cubic feet direct radiation, and $6 per 1,000 cubic feet indirect radiation. They have been in business a number of years, and giving general satisfaction.

SPRINGFIELD, MASS. Population, 62,059

The Springfield Gas Light Co. formerly operated the "Holly system" of steam heating, but discontinued it some years ago. It is reported that the plant was not profitable.

ST. PAUL, MINN. Population, 163,065

The American District Steam Heating Co. are installing a central heating plant at this place, but it is not yet in operation.

ST. JOSEPH, MO. Population, 102,979

St. Joseph Railway, Light, Heat & Power Co. operate a central heating system, furnishing heat to the business houses, public buildings, etc., in the business sections. They use the exhaust system from the light plant for heating, and it is giving satisfaction to its patrons.

SYCAMORE, ILLS. Population, 4,500

The DeKalb-Sycamore Electric Co. operate a central heating system which was installed by the Consolidated Engineering Company. The company has 30,000 square feet of radiation in successful operation for which they receive 35 cents per square foot.

SPRINGFIELD, OHIO. Population, 38,253

The Home Lighting, Power and Heating Co. are operating a central heating system installed by the American District Steam Co. This plant was installed in the summer of 1905, heating the central part of the city with the exhaust steam from their power plant which is located in central part of the city. Their power plant furnishes 75 per cent of the commercial lighting of the city and their income from heating the forty buildings to which they furnish heat, pays their coal bill for the entire plant, leaving a margin of 25 per cent. The company is preparing to extend their system to about thirty more buildings. It

is stated that the system is an entire success and that in zero weather they have never received a complaint.

SPRINGFIELD, ILL. Population, 34,159

The Utilities Co. are operating both hot water and steam heat service from their central plant, which also furnishes power for street railway and commercial lighting. The service is reported to be both satisfactory and profitable.

The Springfield Light, Heat and Power Company, of Springfield, Illinois, has recently built a new power station, for lighting, steam and hot water heating and railway purposes. This power station is notable on account of the size of the exhaust steam heating system supplied from it. In the majority of cities where exhaust steam or hot water heating is being done, the power stations are of much smaller capacity. The heating system of the company at Springfield is one of the largest operated by any electric central station company in the country. About 200,000 square feet of hot water radiators and 150,000 square feet of steam radiators are connected to this station. On account of the exhaust steam heating load, the station is, of course, equipped with simple non-condensing engines.

STATION PIPING FOR HEATING SYSTEM.

The apparatus for hot water and exhaust steam heating occupies considerable space in the power house, and is of much more importance than usual in a power house doing this kind of work. There are two sets of condensers for use in heating water for the heating system which are supplemented by a bank of fuel economizers for utilizing

the heat in the fuel gases. These three means of heating are not sufficient in the coldest weather, and two of the boilers in the station have been fitted up so that they can be completely filled with water and used as hot water heaters. The present arrangement of piping for hot water heating in this station is of interest because it represents the result of the company's experiments and experience along this line. See Fig. 20.

The return water as it enters from the street, first goes through the circulating pumps, from which a 12-inch main takes it to a header to which are connected the six Stahl condensers in multiple. In multiple with these condensers there are also three fuel economizers. After leaving the economizers and first bank of condensers the water passes to the two 3,000-foot Schott condensers. These latter condensers are also connected in multiple. After leaving the Schott condensers, all the water must pass through the water-tube boilers, which are connected in series, unless the by-pass on the boilers is open, in which case, of course, the boilers would be out of use. After leaving the boilers the water flows to the outgoing street main.

The important thing to notice in this piping arrangement, is that the boilers are connected in series with the rest of the heating apparatus. Attempts to operate the boilers in multiple with the other heating apparatus have not resulted satisfactorily.

So far only the connections of the hot water circulating system have been considered. The connections of the condensers to the exhaust steam main which runs the length of the engine room are very simple. These condensers are simply "dead-ended" onto the exhaust main. That is, one end is connected to the exhaust main and the other is closed. The condenser, therefore, takes ex-

haust steam as fast as it can be condensed by water circulating in the condenser. Precautions are taken to let out whatever air that may accumulate in the condenser, just as in a one-pipe steam radiator. The exhaust steam main in the engine room basement is divided by valves into two parts.

STATION PERFORMANCE.

The station was designed with simple non-condensing Corliss engines, for the obvious reasons that the exhaust steam was needed for heating purposes. There is also a further reason that coal is so exceedingly cheap. The economical performance at this station as regards coal consumption is very interesting, because of the light it throws on the question which always comes up in station design where coal is very cheap, viz.: is the saving by compounding and condensing sufficient to pay interest and maintenance on the cost of the compounding and condensing? The coal consumption of this station, during those portions of the year when exhaust steam is not used for heating is about 10 lb. per kw-hour.

The maximum load on the station is now about 2,300 kw.

The hot water heating system is carried as far as one mile from the station. The exhaust steam heating, of course, does not cover so great a distance. The Powers automatic temperature regulators are used on all hot water services to prevent waste of heat. The company find it economical to do this rather than to depend on customers to shut off radiators; when the room gets above a certain temperature the customers' regular method is to open the windows wider.

Steam Rates—Direct radiation, 25c. per square foot per annum; indirect radiation, 30c. per square foot per annum; economizing coil, 15c. per square foot per annum; meter rate, 50c. per thousand pounds water, with discounts for quantity.

Hot Water Rates—Per square foot radiation, 15c. The payments are made in eight installments as follows: October 1, 5 per cent; November 1, 10 per cent; December 1, 15 per cent; January 1, 20 per cent; February 1, 20 per cent; March 1, 15 per cent; April 1, 10 per cent; May 1, 5 per cent.—*Electric World.*

TAYLORVILLE, ILL. Population, 3,800

Plant in operation for about nine years in connection with electric light plant. It is giving perfect satisfaction to both patrons and the company, the plant being a paying investment. The owners of this plant advocate a steam system in preference to hot water, a plant of ample size and the mains not run too great a distance.

TERRE HAUTE, IND. Population, 36,673

The Citizens Mutual Heating Co. have been operating two seasons. The capacity of this plant as now completed is 250,000 square feet of radiation. It is probable than an additional 100,000 square feet will be installed for the winter of 1906-7.

The company has at present 132 patrons. In its present condition, after paying operating expenses, the company states that they will have an excess of $10,000, which will leave a surplus after paying interest on the bonds and 6 per cent on the stock, and if fully loaded, that they could pay 10 per cent or 12 per cent dividend.

The rate charged is 17 cents per square foot of radiation. The Schott two-pipe hot water system is used.

From reports the company is giving entire satisfaction to all its patrons.

The Terre Haute Traction & Light Co. and the Citizens' Mutual Heating Co. both operate central heating systems. The former company only operate a small steam heating system from the exhaust steam from one of its engines. This small plant was one of the first of its kind installed by the American District Steam Co. For the last six years this heating plant has been operated with more success than prior to its purchase by this company, and it is expected by them in the near future to make it at least pay expenses.

The rates charged are as follows:

Business buildings, per season—

For direct radiation	22½c per square foot
For indirect radiation	27½c per square foot
For cooling coils	17½c per square foot

Residences, dwellings, flats, stables, etc.—

For direct radiation	25c per square foot
For indirect radiation	30c per square foot
For cooling coils	17½c per square foot

TOLEDO, OHIO. Population, 131,822

The Yaryan central heating station has been operating in this city a number of years, and is reported to be giving general satisfaction.

TIFFIN, OHIO. Population, 10,989

The Tiffin Edison Electric Illuminating Co. operate a central heating plant in connection with their light plant,

and it is considered a good investment, and giving general satisfaction.

TOPEKA, KAN. Population, 33,608

The Topeka Edison Co. have been operating a central heating system for about nine years. This company has approximately $60,000 invested in their system, and operate same in conjunction with their lighting and power plant, utilizing the exhaust steam as far as possible, supplemented by live steam. They find it necessary to carry from three to six pounds of back pressure on their engines, which are cross-compound.

While this increases the steam consumption per horse-power, this excess load on the engines is better than a corresponding electric road. In other words, with the same boiler horse-power they cannot earn the same net money. Their system is an underground system and was installed by the American District Steam Co.

They sell the steam by the meter system only, the rates charged being as follows:

First 100,000 lbs. water.............60c per 1,000 lbs.
Second 100,000 lbs. water...........50c per 1,000 lbs.
Excess lbs. water..................45c per 1,000 lbs.

The company insist on having supervision over the consumers' piping and on the use of economy or cooling coils, the water of condensation being discharged into the sewer. They have 120,000 square feet of radiation, which heats approximately 10,000,000 cubic feet of space. The average temperature of their locality from October 1st to May 1st is 43.9 degrees.

The service is giving entire satisfaction.

YORK, PA. Population, 33,708

The Edison Electric Light Co. are operating a central heating plant in connection with their power plant, using live steam from the New Haven Power Co. The plant is giving satisfaction to their patrons, and doing a prosperous business.

SUMMARY.

Under ordinary conditions for steam heating one horse power will heat in brick buildings 15,000 to 20,000 cubic feet; in brick stores, 10,000 to 15,000 cubic feet; in brick dwellings, 10,000 to 15,000 cubic feet; in brick churches, brick shops, etc., 8,000 to 12,000 cubic feet; wooden dwellings, 8,000 to 10,000 cubic feet.

The water of condensation in a steam-heating system is led into a steam trap and thence allowed to flow through a "cooling coil," before being discharged into the drainage system.

Where the exhaust steam is used in connection with a hot-water system, the water to be warmed is heated by the steam in large heaters, similar to feed-water heaters, and circulated through the mains by means of centrifugal pumps.

INSULATION AND COST.

The *underground distributing system mains* in either system must be properly insulated or the loss by condensation will be very great.

Fig. 21 shows a form of insulation which has proved quite satisfactory. Using this insulation, the hot water has been sent out through a two-pipe balanced system six and one-half miles or thirteen miles out, and returning at a loss of only 30 degrees, the water being sent out at a temperature of 170 degrees, and returning at 140 degrees.

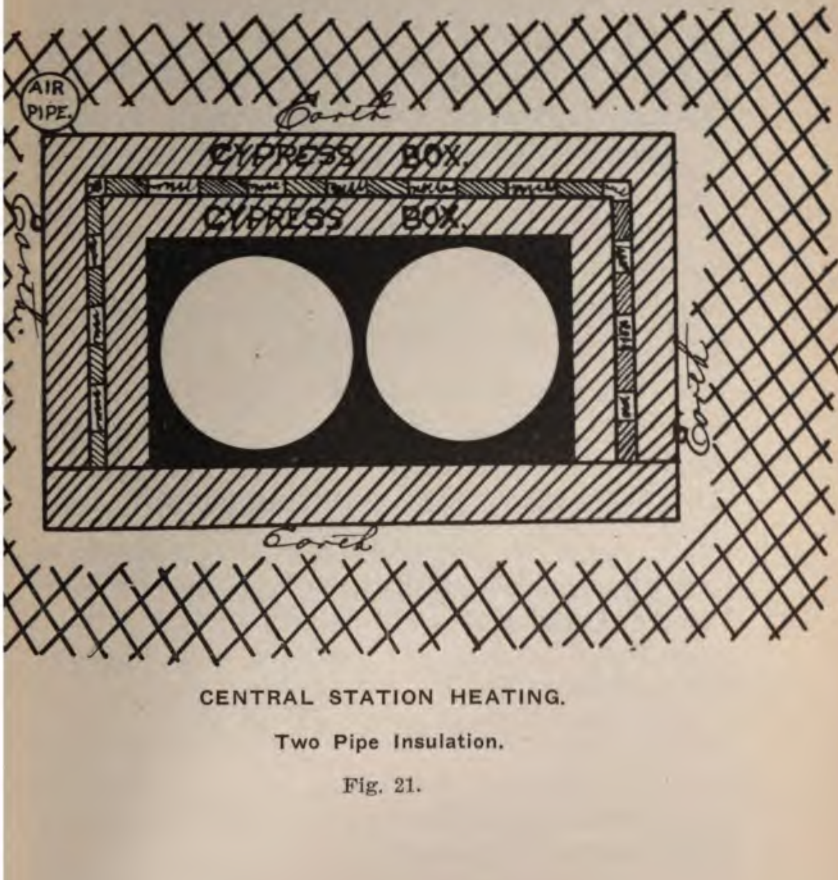
This insulation as shown in the above figure, consists of all mains and laterals being enclosed in two 2-inch cypress boxes ½ inch between each box, which space is filled with hair felt and spaced for air. The inner space around the two pipes is packed with pine shavings. All mains are laid with a cover of at least 2 feet of earth, the mains and laterals being standard full weight wrought iron pipe.

When compressed air is used for the closer regulation of the thermostatic valves, the small air pipe should be laid on top of the outer box, as shown in Fig. 21.

The following is the cost per foot for this insulation for a 12-inch main:

Insulation	$ 1.40
12-inch pipe double main	7.20
Air line	.25
Shavings to fill main	.15
Tar-paper and tar	.15
Labor for excavating	.50
Labor for filling in	.50
Drayage and labor for laying	.75
Tees, expansion joints	2.00
Valves and tapping mains	1.50
Extra insulation for tees and manholes for valves and expansion joints	1.50
Total	$14.40

The cost of a 10-inch, 8-inch, 6-inch and 4-inch main is smaller, but the difference in the cost of the pipe is the main difference in the total cost of insulation.



CENTRAL STATION HEATING.

Two Pipe Insulation.

Fig. 21.

PHYSICAL VALUE OF A TWO-PIPE HOT WATER SYSTEM.

12	inch line	2,350	ft.	$3,238.30
10	" "	580	"	653.23
8	" "	5,550	"	4,147.52
6	" "	6,340	"	2,582.63
5	" "	1,720	"	536.21
4	" "	6,280	"	1,458.21
3	" "	4,730	"	722.15
2½	" "	1,750	"	216.30
2	" "	1,670	"	129.26
1½	" "	550	"	31.96
Total		31,520	ft. single main	$13,695.77
		2		2
		63,040	ft. double main	$27,391.54

INSULATING AND LAYING PIPE PER FOOT.

Insulation, 20c per foot, 63,040 feet	$12,608.00
Laying pipe, per foot $1.30, 31,520 feet	40,976.00
Valves and tapping mains, $1.00 per foot, 31,-520 feet	31,520.00
Extra insulation for T's and manholes, for valves and expansion joints, 50c per foot, 31,520 feet	15,760.00
Air line, 25c per foot, 31,520 feet	7,880.00
Freight and hauling pipe	7,890.08
Boilers, tools and equipments	12,750.00
Building and site	6,000.00
	$162,775.62

RATES CHARGED BY CENTRAL HEATING PLANTS.

In systems using STEAM for heating, the rates charged are based (1) Upon the number of pounds of steam condensed per season; (2) Upon the cubical contents of space to be heated, usually per 1000 cubic feet; (3) Upon the square feet of heating surface installed.

In those systems using HOT WATER for heating, the rates charged are based (1) Upon the number of square feet of radiation installed; (2) Upon the cubic contents of the space to be heated for the season, usually per 1000 cubic feet.

In estimating the amount of heat required to maintain the constant temperature desired, the amount of air to be heated per hour must first be determined, and the heat loss due to glass and wall exposures per hour also determined. With this known, the total heat required can be calculated, also, taking into consideration the average velocity of the wind and the changes of the air each hour, as the average building will have from two to six changes per hour.

Among the leading companies installing central heating plants, is the American District Co., Evans, Almirall & Co., Schott Specialty Co., and the Stahl Heaing Co.

SPECIFICATIONS FOR A COMPLETE HEATING PLANT.

GENERAL.

These specifications are intended to cover a complete heating plant in all details, and if, in these specifications, anything is needed to make the plant complete in accordance with the intent hereof, then in that case it shall be furnished by the contractor without any further charge to the purchaser.

DEFINITION: Whenever the word "purchaser" is hereinafter referred to, it shall be understood to mean the ....Heating Company, of .... Whenever a "contractor" is hereinafter referred to, it shall be understood to mean the .... of .... Whenever a classification hereinunder is specified and no mention is made of either the purchaser or contractor, it shall be understood that the contractor is to do the described work.

REAL ESTATE.

A piece or parcel of land shall be furnished by the contractor to the purchaser, the same to be located ....

POWER HOUSE.

Upon the above-described piece of real estate there shall be installed a substantial brick power house by the contractor, the same to be of neat design and suitable for the purpose of building therein the necessary appurtenances for a complete central station heating plant,

BOILERS.

There shall be installed a sufficient amount of heating surface, the same to be divided into the number of units adapted for the work, sufficient heating surface, together with exhaust steam which is to be furnished to the plant by the company from the power house of the railway and electric company, sufficient capacity to handle at 10 degrees above zero .... square feet of radiation, the same being operated with a hot water circulation. The above-described boilers shall be of the .... or some other water tube type equally as good. They shall be equipped with shaking grates and the necessary tools for the firing of the same.

SMOKE STACK.

A smoke stack of the proper diameter and height shall be installed for each battery of two boilers. Same shall be carried from the top of the boiler settings and maintained by a guy stub set in the proper position.

BOILER FEED PUMPS.

There shall be furnished two bronze-fitted boiler feed pumps; each pump should have sufficient capacity to handle the entire plant with a piston speed not to exceed 100 feet per minute.

FEED WATER HEATER.

There shall be furnished a feed water heater and purifier of sufficient capacity to furnish boiler feed water for the number of boilers that will be necessary for the operation of the plant in question. It shall also be of sufficient size to purify the water used in the heating system.

CIRCULATING PUMP.

There shall be furnished two bronze-fitted special designed hot water circulating pumps, to be used for the purpose of circulating the water in the heating system. They shall have a capacity of not less than fifteen gallons of water each per minute. They shall be erected upon the proper foundations by the contractor and equipped with automatic governors.

PLACING, REGULATING AND RECEIVING PUMPS.

There shall be furnished the necessary pumps, the same erected upon foundations and equipped with an automatic governor to relieve the apparatus from condensation, maintain the necessary vacuum on the system, and to make the plant complete in all its details.

VACUUM PUMPS.

There shall be installed a vacuum pump of sufficient capacity, the same to be bronze-fitted throughout, to handle the exhaust steam which is to be received from the .... plant. Same shall be erected complete upon foundation to be furnished by the contractor.

CONDENSERS.

There shall be furnished two condensers, one of ...... feet size, one of ...... feet size. The same shall be delivered and erected complete upon foundations furnished by the contractor.

PIPE CONNECTIONS.

The contractor shall furnish all necessary valves, fittings, pipe, labor, etc., so as to connect up all the above

described apparatus so as to be complete in all its details and in a good and workmanlike manner.

PIPE COVERING.

After all of the appartus has been installed and connected, all pipe and fitting shall be covered with an approved pipe covering.

AIR COMPRESSOR.

There shall be furnished one air compressor, same having a capacity of . . . feet of free air per minute. The same shall be equipped with the necessary regulators, storage tanks, etc.

GAUGE BOARDS.

There shall be furnished one marble gauge board, the same having mounted thereon all the necessary gauges, thermometer, etc., for the indicating of the proper workings of the system.

PIPE LINE.

The pipe line to be laid in the various streets in the city of .... shall be laid by the contractor and shall consist of the following pipe lines:

...... feet of 14-inch main.
...... feet of 12-inch main.
...... feet of 10-inch main.
...... feet of 8 inch main.
...... feet of main which shall be of such average sizes so as to equal the cost of 6-inch main.

LOCATION OF MAINS.

The mains shall be located in such parts of the streets as found convenient on account of construction conditions. The mains shall be so laid as to have a cover of earth of at least two feet, excepting in such places as

obstructions are encountered; then, in that case, the minimum depth from surface of street of top of insulation shall be at least twelve inches.

MATERIALS.

The materials to be used in the construction of the pipe lines in question, shall consist of gum lumber of the proper thickness and lengths, the same to be of a first-class quality.

The pipe shall be of standard wrought full-weight pipe, of the Crane or National Tube Company's manufacture, or something equally as good. All fittings shall be of standard grey iron and true as to weights, etc. The pipe lines shall be protected throughout with a system of valves and expansion joints. Wherever valves or expansion joints are put into the system, they shall be surrounded with a brick manhole with a cast iron top, so as to permit of free access to the same. The expansion joints shall be so arranged that there will not be any undue strain on any of the fittings in the system.

SERVICE OPENINGS.

Service openings shall be made in the system as needed to provide for the taking off of service connections. They shall average at least one to every 100 feet of main.

TEST.

As the street work is installed, it shall be tested, so as to be tight under a pressure of not less than 60 pounds.

RE-PAVING.

Whenever any of the lines are laid in streets which have been paved, the pavement shall be replaced in as good a condition as found.

TIME OF COMPLETION.

The work herein contemplated shall be completed and in full running order by ...., in accordance with the minimum terms of the franchise.

FINALLY.

During the construction of the plant the contractor shall furnish all the engineers and superintendents necessary for the complete building of the plant, together with the measuring of the buildings and making of contracts for the heating of the buildings. As soon as the plant is ready for operation the purchaser shall measure all buildings and make all heating contracts and shall provide the necessary attendants for the operation of the plant, together with all the necessary fuels and materials for the proper operation of the same. The contractors shall furnish for a period of thirty (30) days, if necessary, an expert to instruct the superintendent of the heating company in the proper management and operation of the plant.

GUARANTEES.

The contractor guarantees the plant shall be complete in all details and operate successfully as a central station heating plant, and any defects developing in one year shall be replaced by contractor without expense to purchaser.

SYSTEM.

The system shall be what is known as ...., and shall be built under the direction of ....

CONTRACT FOR SUPPLYING EXHAUST STEAM FOR HEATING.

This contract and agreement between the .... Company, the party of the first part, and hereinafter designated the "Vendor," and the .... Heating Company, the party of the second part, hereinafter designated the "Purchaser," witnesseth:

That the vendor does agree to sell to the purchaser the use of the exhaust steam from its main engines for the purpose only of heating water distributed by the purchaser to buildings in and around the city of ...., on the following conditions, each of which is a part of the consideration in this agreement:

First—That vendor shall supply an outlet from the exhaust of each main engine in its power house on ...., and from this point purchaser shall install and maintain at its own expense all pipe, valves, fittings and accessories, necessary to conduct the exhaust steam from the engines of the vendor to the plant of the purchaser, and the condensed steam from the plant of the purchaser to the hot well in the power house of the vendor, according to plans approved by the vendor and in a manner satisfactory to the vendor, and in such a manner and at such times as, in the opinion of the vendor, will not interfere with the operation of the vendor's plant, provided that the vendor shall not impose conditions on the prosecution of the work such as to prevent the completion by the purchaser of its work inside the power house in sixty (60) working days.

Second—That purchaser shall pass through its heaters part, or all, of the exhaust steam delivered by the main

engines of the vendor between November 1, 1906, and May 1, 1907, and for the last three and first four months of each succeeding year during the life of this contract, and shall pay for the use of this steam three and eighty-five one-hundredths (3.85) cents for each one thousand (1,000) pounds of steam received.

It is further agreed by the purchaser that the total payment between November 1, 1906, and May 10, 1907, shall be not less than .... ; that the total payment between October 1, 1907, and May 10, ..., shall be not less than .... ; that the total payment between October 1, ..., and May 10, ..., shall be not less than .... ; that the total payment between October 1, ..., and May 10, ..., shall be not less than .... ; and between October 1, ..., and May 10, ..., not less than .... If the purchaser shall fail to use between October 1 of each year and May 10 of the following year, seventy-five per cent (75%) or more of the exhaust steam output of the main engines of the vendor, then the vendor may terminate and cancel this contract on thirty (30) days' notice to the purchaser, unless the purchaser shall, upon receipt of said notice, pay the vendor such an amount as, together with the previous payments for steam furnished since the 1st of October preceding, will make up the full value of seventy-five per cent (75%) of the exhaust of the vendor's main engines at the above mentioned price.

In case of dispute as to the amount of the output of exhaust steam, this amount in pounds shall be considered to be the number of kilowatt hours output of the vendor's station during the time under dispute, multiplied by thirty (30).

The amount of steam furnished by the vendor shall be measured by passing it, after condensation, through two (2) water meters, one furnished by the vendor and one by the purchaser. These meters shall each be read jointly by a representative of the vendor and a representative of the purchaser, on the first of each month during the heating season, and payment at the above rate shall be made by the purchaser to the vendor not later than the tenth of each month or the number of pounds of steam furnished the purchaser during the preceding month, as shown by the average of the readings of the two (2) meters. Either the purchaser or the vendor may at any time cause either meter to be removed and tested, provided that the expense of such removal and test shall be borne by the party requesting it. In the absence of the second meter the reading of the remaining meter alone shall be considered as the correct measure of steam furnished. The accredited representative of the vendor shall have the right at all times to enter the plant of the purchaser and to inspect same to insure the return to the vendor of all steam delivered to the purchaser.

The representative of the purchaser shall have access to the plant of the vendor at all times to inspect and repair the pipes and accessories belonging to the purchaser, provided, however, that no repairs on the premises of the vendor shall be made except at such time and in such manner as the engineer in charge of the vendor's station shall specifically permit, and provided that no representative of the purchaser shall open, close, or tamper with any valve or apparatus on the premises of the vendor without the specific permission of said engineer in charge of the vendor's station.

Third—The exhaust from pumps, exciter, engines and other auxiliaries connected with the power house of the vendor shall not be considered as part of the above-mentioned exhaust steam from main engines.

Fourth—The purchaser shall use all the exhaust from the engine or engines at any given time connected to its main, before demanding the connection of an additional engine.

Fifth—The purchaser shall give the engineer in charge of the vendor's power house not less than thirty (30) minutes' notice of its desire to have cut in or out each engine to be connected to or disconnected from its main.

Sixth—Nothing in this agreement shall require the vendor to run more engines than it deems necessary for its own purposes, and the vendor shall at all times be free to run such engine or engines as in its own opinion are most suited to its own purposes.

Seventh—The purchaser shall return, condensed, to the hot well of the vendor above mentioned, all of the steam received from the vendor at a temperature not less than 110° Fahrenheit, without having contaminated it with oil or otherwise.

Eighth—The purchaser shall maintain on the exhaust of each and every engine connected to their main vacuums not less than the following:

At no time less than	10 inches
When the temperature of the external air is not less than	10° F. vacuum not less than 11 inches
Same	20° F. vacuum not less than 12 inches
"	30° F. vacuum not less than 15 inches
"	40° F. vacuum not less than 16 inches

Same	50° F. vacuum not less than 18 inches	
"	60° F. vacuum not less than 20 inches	
"	65° F. vacuum not less than 24 inches	

It is understood and agreed between the vendor and purchaser that the above external temperature shall be that reported by the U. S. weather bureau for the city of ....

Ninth—It shall be optional with the vendor to supply at any time live steam at the pressures above enumerated in place of part or all of the exhaust steam of its main engines and in case the vendor elects to furnish live steam the amount in pounds to be considered equivalent to the exhaust steam produced during the time live steam is substituted, shall be the number of kilowatt hours produced by the purchaser during the same hours of the same day or days of the preceding year, plus fifteen per cent (15%) and multiplied by thirty (30).

Tenth—In case of break down or accident in the power house or any part of the plant of the vendor, which break down or accident shall partly or wholly prevent the vendor from furnishing exhaust steam as herein agreed, the vendor shall not be liable for any claim or claims for damages arising from said failure to furnish steam.

Eleventh—The purchaser hereby agrees not to generate electricity for any purpose whatever, and further not to buy or use exhaust steam or waste heat in any form from any plant, party partnership or corporation generating electricity, manufacturing gas, or using gas or other hydro-carbon for power generation, or in any way competing with the vendor. The purchaser further agrees not to pass through its works, pipes, or mains any water or other fluid heated by any plant other than its own, and further to purchase no steam or heat in any form except

coal, oil, wood, or garbage for consumption in its own plant until it shall have utilized all the exhaust steam from the vendor's plant.

Twelfth—It is understood and agreed, by and between the vendor and purchaser that no charge other than those above mentioned shall be made for the location of the pur-vendor require the alteration of the location of said pipe chaser's pipe lines on the property of the vendor or for the attachment of the purchaser's water supply line to the intake of the vendor, but that should the plans of the lines of the purchaser, the purchaser shall make such alterations as may be specified by the vendor within thirty (30) days from receipt of written notice to do so, provided that the purchaser shall not be required to make during the last three or first four months of any year any alteration which will necessitate the total or partial shut down of the plant.

Thirteenth—The duration of this contract shall be ...... years from date of signature unless cancelled on account of non-fulfillment of one or more of the above conditions.

CHAPTER IX.

ELEMENTS OF ELECTRICITY.

As no incinerating plant can be made a financial success unless the waste heat is utilized either for power or heat, no city official or engineer can pass intelligently upon the merits of any incinerator plant or system who is not familiar with at least the elements of electricity, which is the chief product from the utilization of such heat. From electricity is produced light and power, light for the streets and buildings, and power to operate the motor mills, rock crushers, and the other municipal works.

What is electricity is not known. It is invisible and impalpable. Our knowledge of it is confined to its generation and application, but this alone is of moment to the official or engineer. Without this knowledge, all plans and specifications for incinerating plants become unintelligible, and place municipalities at the mercy of the contractor.

The subject of electricity is divided into

(1) Static electricity, or electricity at rest.
(2) Current electricity, or electricity in motion.
(3) Magnetism, or electricity in rotation.
(4) Electricity in vibration or radiation.

But only *current* or *dynamic electricity* will be considered in this work, as it covers most of the field of the uses of electricity in the utilization of waste heat.

The production of electricity is the transforming of one form of energy into another, usually by mechanical means, and a dynamo or generator is simply a device for effecting such transformation.

An electric motor, on the contrary, is a device for changing electrical into mechanical energy.

An electric current manifests itself by the heating of the wire or the conductor through which it passes, or by causing a magnetic field around the wire or conductor, or lastly, by causing chemical changes in a liquid through which it is made to pass.

All these manifestations indicate the character of useful work capable of being performed by an electric current. First, the heat caused by the resistence of the conductor through which the current passes, is made to generate light and heat. Second, the magnetic field around the wire or conductor is used to operate all character of electrical machines and motors and also make high voltage currents safe and practical by the use of transformers. Third, the chemical changes brought about in the liquid by the passage through it of the current is used for the storage of electricity to be later used, as needed.

STORAGE BATTERIES.

Storage and secondary batteries, also called accumulators, consist of cells which are filled with the liquid in which the chemical change is to be produced by the passage of an electric current through it.

The current decomposes the liquid, or electrolyte, as it is called, so that when the passage of the current ceases there are two chemical elements separated, and with a tendency to reunite, and during the process of again com-

bining the energy evolved appears as an electric current, but flowing in an opposite direction to that of the charging current. This flow of current continues until the elements are restored to their original condition, when it ceases, and the cell is said to be discharged.

An *electrolyte* is a chemical compound which is capable of acting as an electric conductor, and while so acting undergoes chemical decomposition. This action is called *electrolysis.*

A *primary cell* is one in which the electric energy is produced by the chemical action on the plates of the cell, and which, when the solutions or plates are exhausted, are *not* restored to their original condition by the passage of an electric current. Almost all primary cells will act more or less perfectly as secondary or storage cells.

CIRCUIT.

A circuit is a path composed of a conductor, which is usually copper wire, through which an electric current flows from a given point around through the conductor back again to the starting point. There is no actual flow of the current, for there is no transfer of matter or particles. A conductor carrying a current presents the same appearance as one not, the only manifestation being the heating of the conductor, should the capacity of the wire be too small for the current carried. The flow of the current is caused by the difference of potential, and the greater the amount of potential difference, the greater is said to be the pressure or electromotive force, usually written E. M. F., or voltage which causes the flow. The strength of the current flowing through the conductor depends directly upon the amount of this electromotive force and

also upon the amount of the resistance to the flow. If the circuit is short and composed of good conductors, the current will be much stronger than if it were long and composed of poor conductors.

The three principal units used in the measurement of a current of electricity are:—

The *Ampere*, or the unit denoting the rate of flow of the current, or its *strength*.

The *Volt*, or the unit of electrical potential, or *pressure*.

The *Ohm*, or the unit of resistance.

The *Watt*, or the unit of power, and is obtained by multiplying the current by the voltage, or by multiplying the square of the current by the resistance.

For large units the term kilowatt is used, which is equal to 1,000 watts, the abbreviation being K. W. The kilowatt hour is the energy expended in one hour when the power is one kilowatt.

The relation of the first three units can be better understood by the analogy often used of the flow of water through a pipe. The force which causes the water to flow through the pipe is called the head, or *pressure*; that which resists the flow is the friction of the water against the pipe, while the rate of flow, or current, may be expressed in gallons per minute. Now as the pressure or head increases, the rate of flow or current increases in proportion, but as the resistance increases the current diminishes.

In the case of electricity, the electromotive force, or potential, corresponds to the head of water, or pressure; and the resistence of the conductor, to the friction of the water against the pipe; while the *strength* of the current is the ratio of the electromotive force to the resistance of the conductor. This ratio was discovered by Dr.

Ohm, and is therefore called Ohm's law, and is the foundation of applied electricity, for there is hardly a problem in electrical work that it does not enter.

This law is usually expressed algebraically, thus:

$$\text{Strength of current} = \frac{\text{ELECTROMOTIVE FORCE}}{\text{RESISTANCE.}}$$

$$\text{or Amperes} = \frac{\text{VOLTS}}{\text{OHMS.}}$$

$$\text{or } C = \frac{E}{R}, \text{ as it is commonly expressed,}$$

in which C equals current, E equals the electromotive force expressed in volts, and R equals resistance, expressed in Ohms.

From this formula is derived $E = C \times R$, or $R = \frac{E}{C}$, these terms all being dependent upon each other. For watts we have the formula $W = E \times C$.

With any two of these terms given, it can be seen that the third term can readily be found. As seen, the current varies *directly* as the voltage varies and *indirectly* as the resistance varies. That is, the current increases when the voltage increases and decreases when the resistance increases. With the above four formulas any calculation in electricity becomes most simple. For instance, suppose you wish to find what current will flow through a resistance of 3 Ohms, at a pressure of 6 volts.

Substituting in formula (1), we have C (amperes) equals $\frac{6}{3}$ equals 2 amperes.

Again, we have a lamp the resistance of which we know to be 12 Ohms, and we are using 2 amperes of current; what E. M. F. (volts) is necessary?

Using formula (2) we have E (volts) equal 2 x 12 equal 24 volts.

Suppose we wish to know the resistance of a wire coil through which a current of 6 amperes will pass with 20 volts pressure?

Substituting in formula (3), we have R (Ohms) equal $\frac{20}{6}$ equals 3 1-3 Ohms. Lastly, we have a small motor taking 2 amperes at 5 volt pressure to run it, how many watts of current does it consume?

Substituting in formula (4), we have W (watts) equals 2 x 5 equals 10 watts.

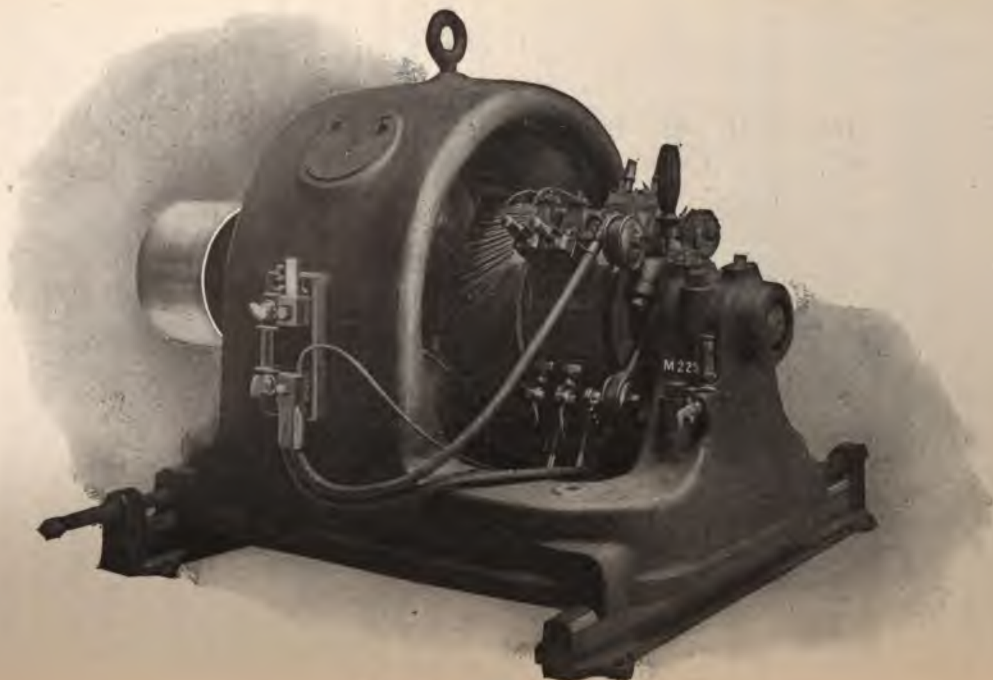
ALTERNATING AND CONTINUOUS CURRENTS.

Two kinds of electricity are generated by a dynamo or generator, distinguished by the direction of their flow. The continuous or direct current flows continuously in one direction, while the alternating current alternates the direction of its flow back and forward the entire length of the circuit. These alternations may be ten thousand times a second or only a hundred a second, this being called the frequency of the alternations. For lighting it is necessary to have at least forty complete alterations per second. The direct current is a constant and unvarying current, and the machines used for its generation are divided in two types:

(1) Constant Potential Dynamos, in which machine, although the *pressure,* or voltage may vary, the *amount* of the current does not.

(2) Constant Current Dynamos, in which machine, although the *strength* of the current may vary, the *pressure,* or voltage, remains constant.

Each of these currents have their advantages and adaptability for their particular classes of work, as will be



Type of Electric Generator.
Fig. 22.

shown later. All current when first produced by a dynamo or generator is alternating, and to send it out as a direct current, it is necessary that it be changed upon the machine before transmission, and the addition of the commutator to make this change practically constitutes the only difference between a direct and an alternating current dynamo or generator.

THE DYNAMO.

(Fig. 22.)

The dynamo is a machine driven by power, usually steam or water, and producing the necessary pressure for the production of an electric current.

A dynamo when in action is like a cistern at a high level, or a pump, for it urges or forces the current through the conductor. Without such force or pressure as produced by the dynamo, there would be no more flow of an electrical current, than there would be of water from one receptacle to another, when they are on the same level.

Dynamos are classified into (1) Uni-polar, (2) Bipolar, (3) Multi-polar machines, according to the number of pole pieces upon them, and they are used for three principal purposes:

1. Incandescent lighting.
2. Arc lighting.
3. For distribution of power.

When used for power purposes, the machine is called a generator, that is, when it generates electricity to be used through motors. This machine in its simplest form consists of two main parts: (1) an armature, which in revolving induces electromotive forces in the conductor wound upon it; (2) a field magnet, whose function is to

provide a field of magnetic lines to be cut by the armature conductors as they revolve. In all dynamos, whether for direct or alternating currents, these two parts are the same. Usually the field magnet remains stationary while the armature rotates, but in recent patterns of alternators, the armature remains stationary, and the field magnets rotate.

It is always the field magnet which maintains its magnetism steady during the revolution, while the magnetism of the armature alone regularly changes and this variation of the magnetism determines the type of machine. It has been found most convenient to supply incandescent lighting systems by the constant *potential* system, and arc lighting systems by the constant *current* system.

The essential difference between a direct current machine and an alternator, as an alternating current machine is called, is the use of a commutator upon the former machine for rectifying the current, that is, to change it from an alternating to a direct current. The commutator is attached to the armature and revolves with it.

In the case of an alternator there is no need of a commutator, but metallic rings, known as collecting rings, takes its place, the collecting brushes pressing against them.

The dynamo, therefore, is seen to consist of five essential parts, viz.:

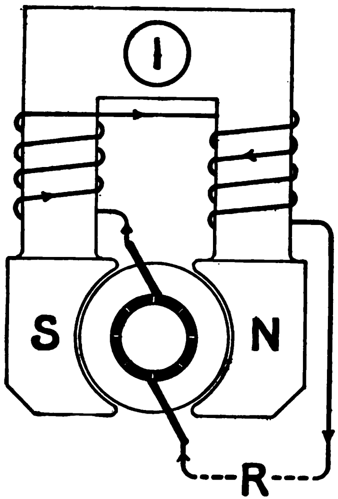
(1) The armature, or revolving part.

(2) The field magnets which produce the magnetic field in which the armature rotates.

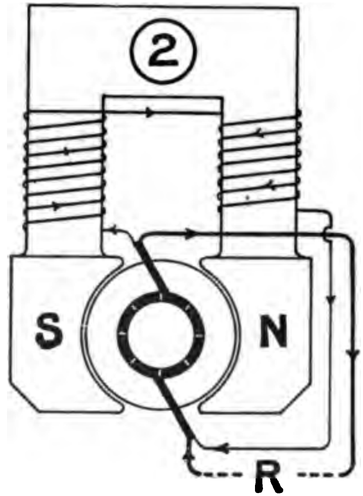
(3) The pole pieces.

(4) The commutator or collector.

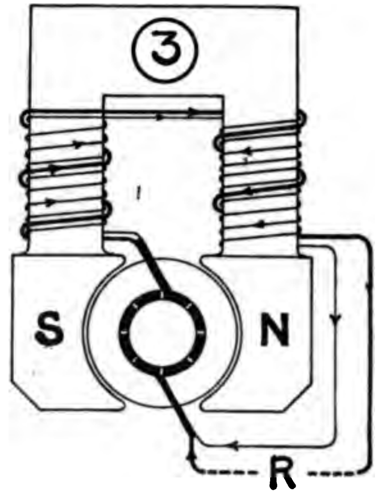
(5) The collecting brushes.



Series Wound.



Shunt Wound.



Compound Wound.

Classes of Electric Generators.
Fig. 23.

TYPES OF DYNAMOS.

There are two principal types of dynamos: (1) Direct current, and the (2) Alternating current machine.

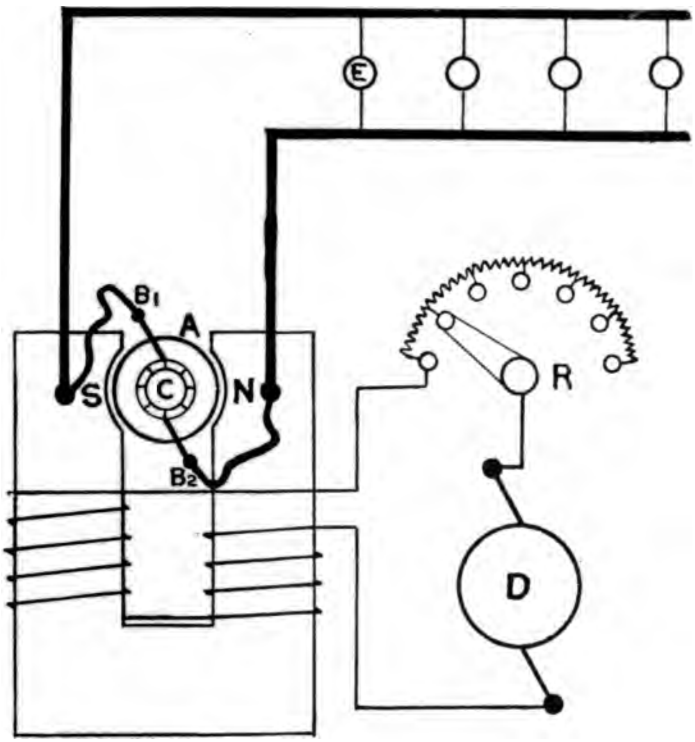
The direct current machines are divided into three classes: (1) Series wound; (2) Shunt wound; (3) Compound wound, depending upon the manner the field magnets are connected to the armature.

SERIES DYNAMO.

The manner in which the connections are made on this type of machine can be seen from Fig. 23. In this type, the *whole* of the current generated in the armature, passes direct through the coils of the field magnet, which is wound with several turns of heavy wire, and thence out to the external circuit. The current in passing through the coils of the field magnet energizes same, creating a magnetic field between the N. & S. poles, in which magnetic field the armature revolves as shown clearly in the cut.

SHUNT WOUND DYNAMOS.

This type which is shown in Fig. 23, differs from the series wound machine in that the *whole* of the current does *not* pass through the field coils, but an independent circuit is used for exciting its field magnet. This independent circuit is composed of a large number of turns of fine wire, which are wound around the field magnet and connected direct to the brushes, so as to form a by-pass or shunt to the brushes and external circuit, in addition to the main current, which is taken off direct from the brushes. There are two paths presented to the current as it leaves the armature, viz.: The external circuit and



WINDING FOR SEPARATELY EXCITED DYNAMO
Fig. 24.

the path through the field coils. Most of the current flows through the external path, as it offers much less resistence than the shunt path through the field coils, it being of much larger wire. The resistance of the shunt circuit is always made very great, as compared to the resistence of the armature and external circuit, as this circuit is used alone to secure a closer regulation of the machine than afforded by the series type. The strength of the current through the field coils rarely exceed 15 amperes, even in the largest size machines.

COMPOUND WOUND DYNAMOS.

This type, as shown in Fig. 23, is a combination of the series and shunt wound machines, the field magnet being wound with two sets of coils, one set being connected in series, and the other set in parallel with the armature and external circuit.

This affords a much closer regulation than the shunt type, and automatically maintaining a constant pressure, and is therefore used almost exclusively for incandescent lighting.

The above three types are what is known as *self-exciting machines*, as they require no independent battery or dynamo for exciting their field magnets, but excite their fields themselves, as above described.

ALTERNATORS.

In order to operate this type of machine, which is shown in Fig. 24, an independent direct current dynamo or battery is necessary for exciting its field magnets, called an exciter. It is therefore not in general use for small installations, being principally used where an alternating current is required, as with an alternating current a self-

exciting machine is impossible, owing to the fact that the fields can not be magnetized with such a current.

The E. M. F. and current of this type of dynamo is regulated by varying the strength of the magnetizing current produced by the independent dynamo or battery which is connected direct to the field coils. The strength of this independent current is regulated by the regulator R.

CONNECTING OF DYNAMOS.

In large installations, such as central generating stations, it is neither economical or desirable that the entire current should be furnished from a single dynamo or generator. As it is economy to always work a dynamo at full load, or as near a full load as possible, it is manifest that this would be impossible with only one machine, owing to the fluctuation of the load. In order to secure a maximum efficiency it is usual to divide up the plant into a number of units, so that the load can be taken care of at all times, irrespective of its fluctuations. At the "peak" of the load all the units can be worked, and as the load decreases the units can be cut out, so as to always keep a full load on the machines kept running.

The output of a dynamo is composed of two factors, the pressure, or voltage, and the current, or amperage. Either or both of these can be increased by the addition of more machines, the same as the boiler horse power of a plant can be increased by the installing of more boilers. The uses of electricity at the present time require the maintenance of either a constant current, or a constant pressure in a circuit, and to comply with these requirements it becomes necessary to connect the dynamos or generators together in several different ways.

In coupling two or more machines in parallel the pressure or voltage of all the machines are kept constant, and the current or amperage alone varies.

In the series connection the pressure or voltage of the machines is increased, while the current, or amperage, remains the same.

Fig. 25 shows the cells when completed in series and also when connected in parallel. Also connection of lights in series and parallel.

Fig. 26 shows the principal systems of connected lights.

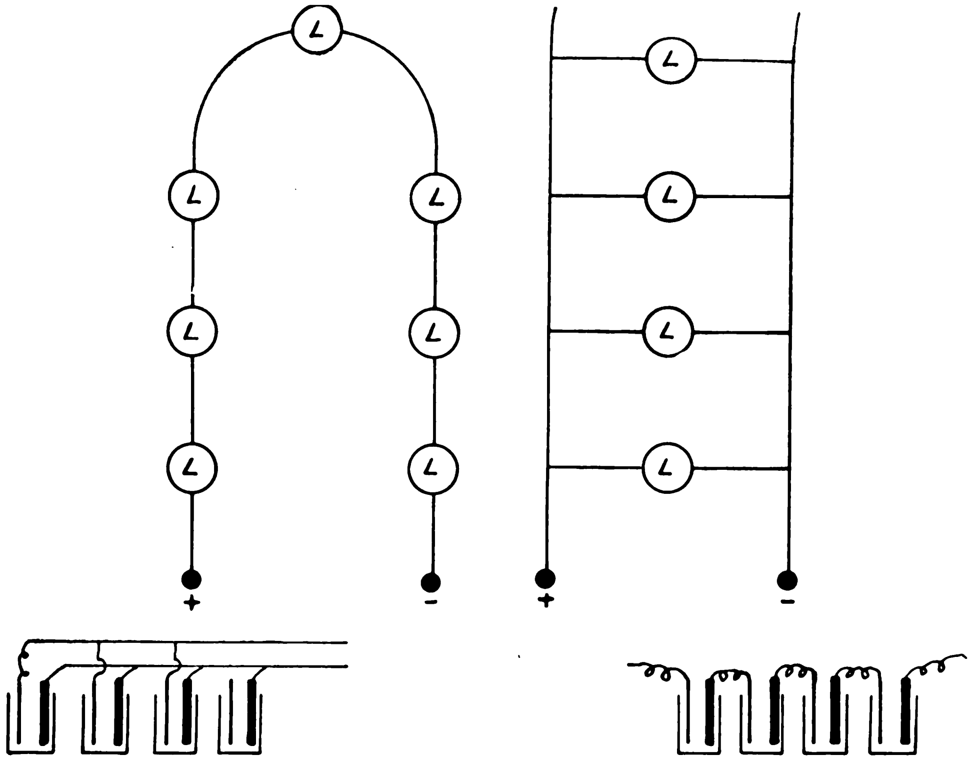
When the machines are connected in *parallel* all the positive terminals are connected together, and all the negative terminals the same way; or the positive and negative terminals of each machine can be connected respectively to two insulated copper bars, called omnibus or "bus" bars. When in *series*, the negative and positive terminals are connected to each other.

SHUNT DYNAMOS IN SERIES.

This is the usual method of connecting up dynamos so as to run either in parallel or series. To connect in series the positive terminal of one machine is connected to the negative terminal of the other. The ammeter, fuses and switch are connected through the outer terminals, as shown in Fig. 27.

SHUNT MACHINES IN PARALLEL.

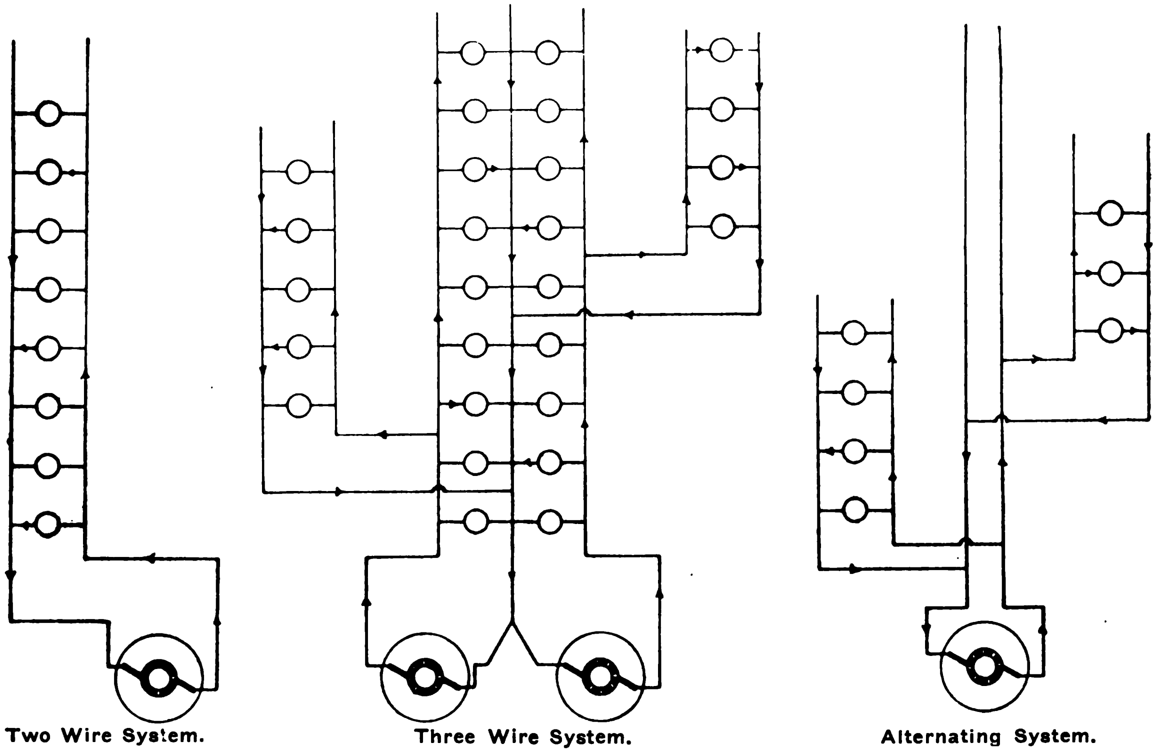
To connect shunt machines in parallel, it is only necessary to connect the positive and negative terminals of each machine respectively to the positive and negative "bus" bars, as shown in Fig. 28.



Cells in Parallel.

Cells in Series.

Connection of Cells and Lights in Series and Parallel.



Systems of Connecting Lights.
Fig. 26.

SERIES DYNAMOS IN SERIES.

Series wound machines will run satisfactorily when connected in series, as shown in Fig. 29.

SERIES DYNAMOS IN PARALLEL.

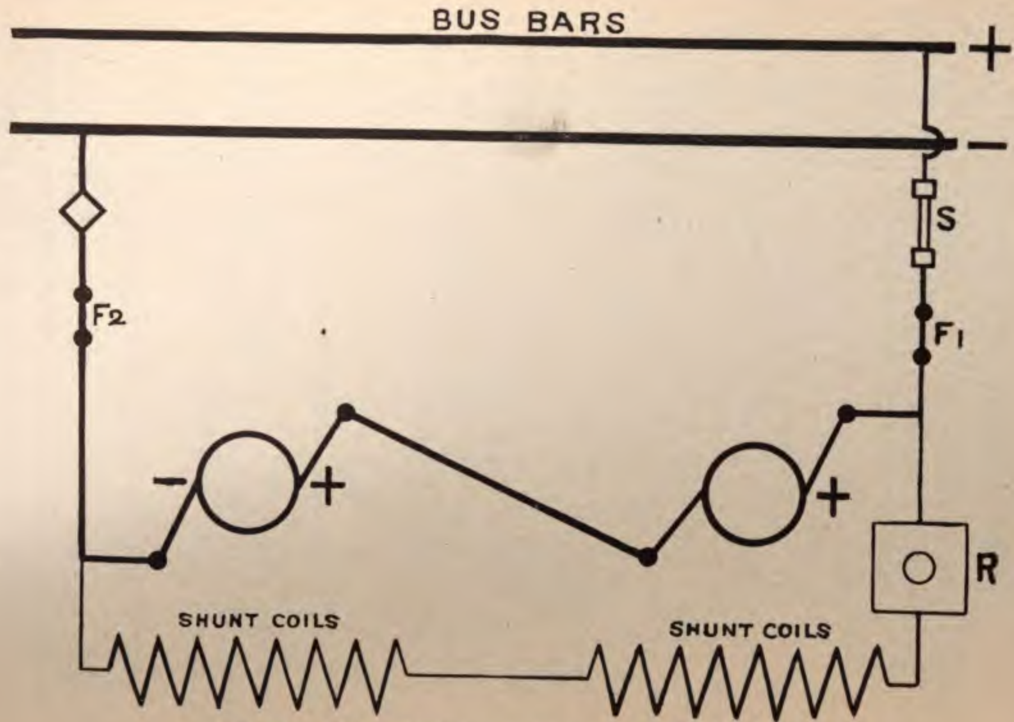
Series wound machines are not adapted to run in parallel, as machines of this type are not constructed for the purpose of maintaining a constant pressure. In order to operate such machines in parallel, an "equalizer" is necessary, as shown in Fig. 30. This is a third connection between the ends of all the series coils, where they join the armature circuit. This causes the whole of the current generated by all the machines to be divided among the series coils of the several machines. This maintains constant the fields of the several machines, and maintains an equality of pressure, thereby preventing reversal of polarity, and keeping the machines together under all conditions of load.

COMPOUND DYNAMOS IN SERIES.

It is only necessary to connect the series coil of each together, as shown in Fig. 29. The shunt windings must be connected as a single shunt.

COMPOUND DYNAMOS IN PARALLEL.

Such machines will not run together satisfactorily unless the series coils are connected together by an equalizing connection, as shown in Fig. 32. The connection is the same as when series dynamos are connected in parallel.



SHUNT DYNAMOS IN SERIES

Fig. 27.

COUPLING OF ALTERATORS.

In order that the output of one alternator may be added to another it is necessary that the E. M. F. of each machine shall be in exact agreement, so that they will have equal frequencies, or be *in phase,* or *in step* with each other.

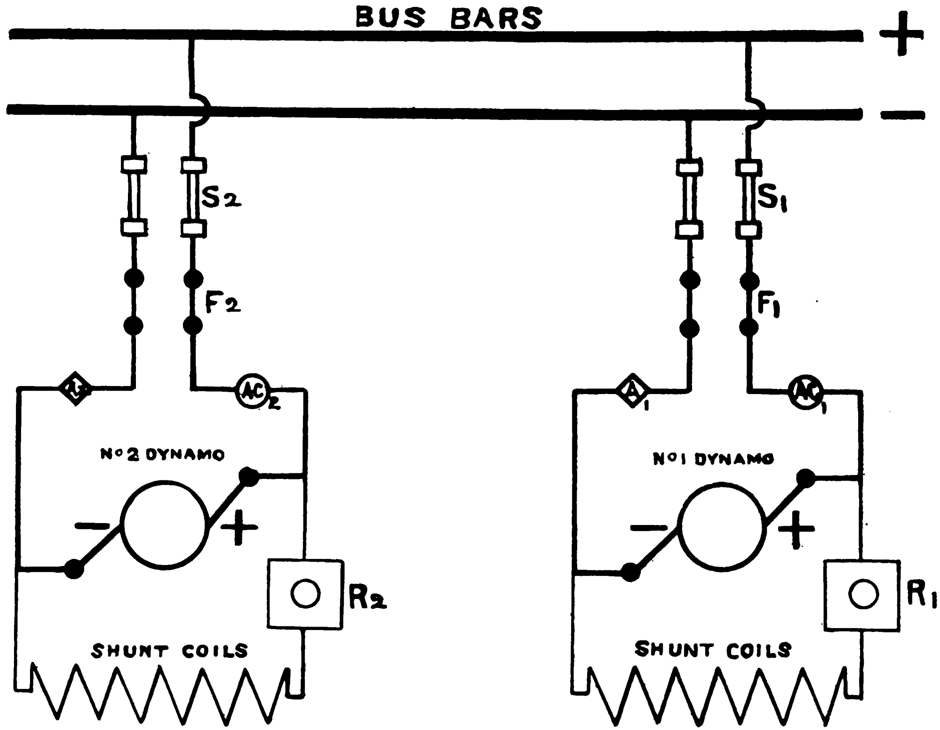
METHOD OF MEASUREMENTS.

To ascertain the amount of current flowing in a circuit an ammeter, which is designated in Fig. 33 as A, is inserted in *series* in one of the mains. The whole of the current passing to the lamps L, therefore must pass through it and be measured.

A voltmeter, designated as V, is connected across the two main leads, or in *shunt* with the dynamo, and therefore measures the difference of potential between the two mains in volts.

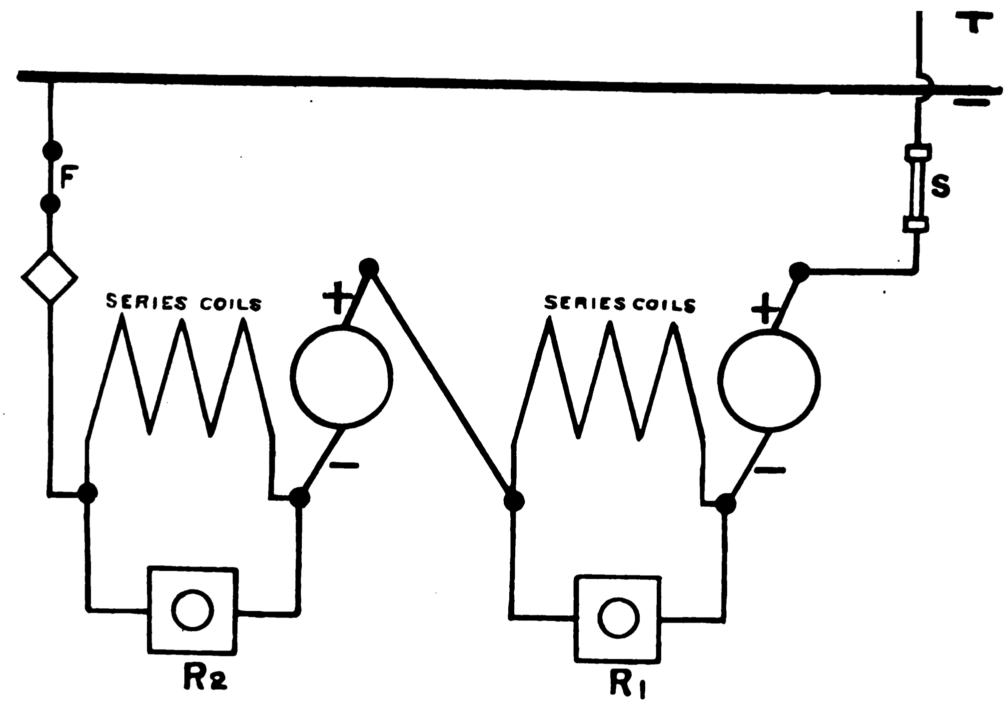
USE OF DIFFERENT TYPES.

The series wound machines are used almost exclusively for street car motors, such a type being totally unfit for constant potential work. The shunt and compound wound machines are practically used for all power and incandescent lighting circuits. The constant current type is devoted mostly to arc lighting. Of the three types described above, the compound wound machine is by far the most used, owing to its close and automatic regulation.



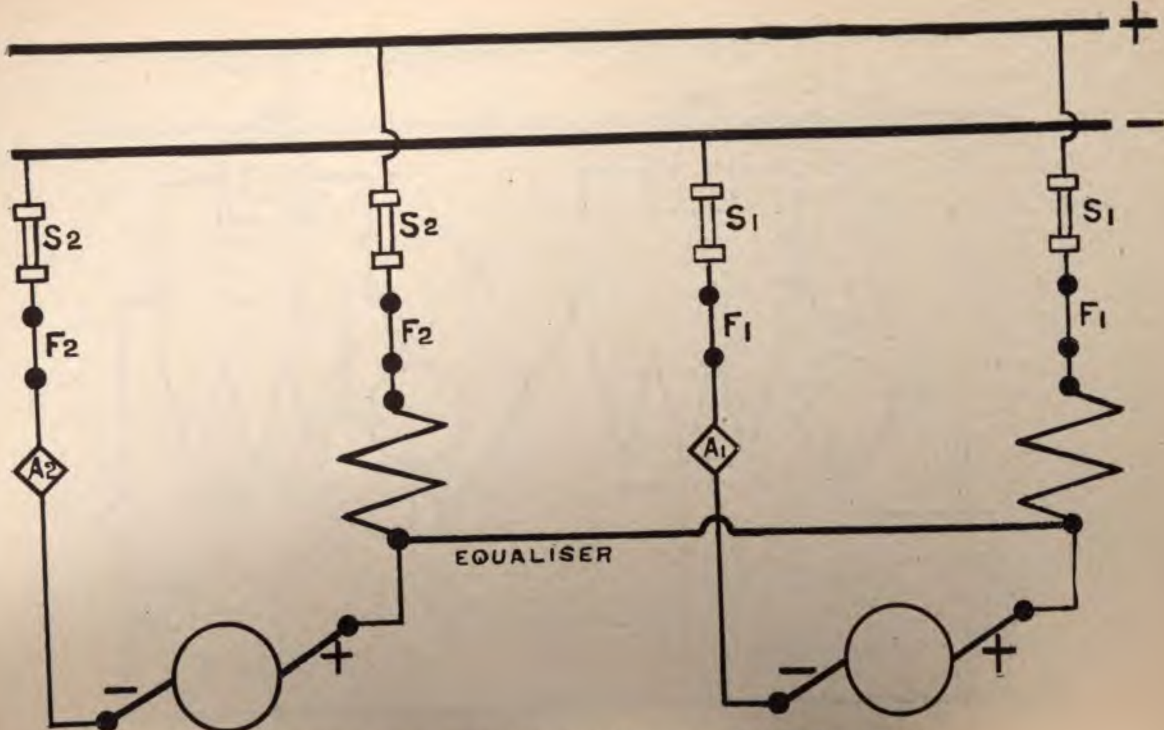
SHUNT DYNAMOS IN PARALLEL

Fig. 28.



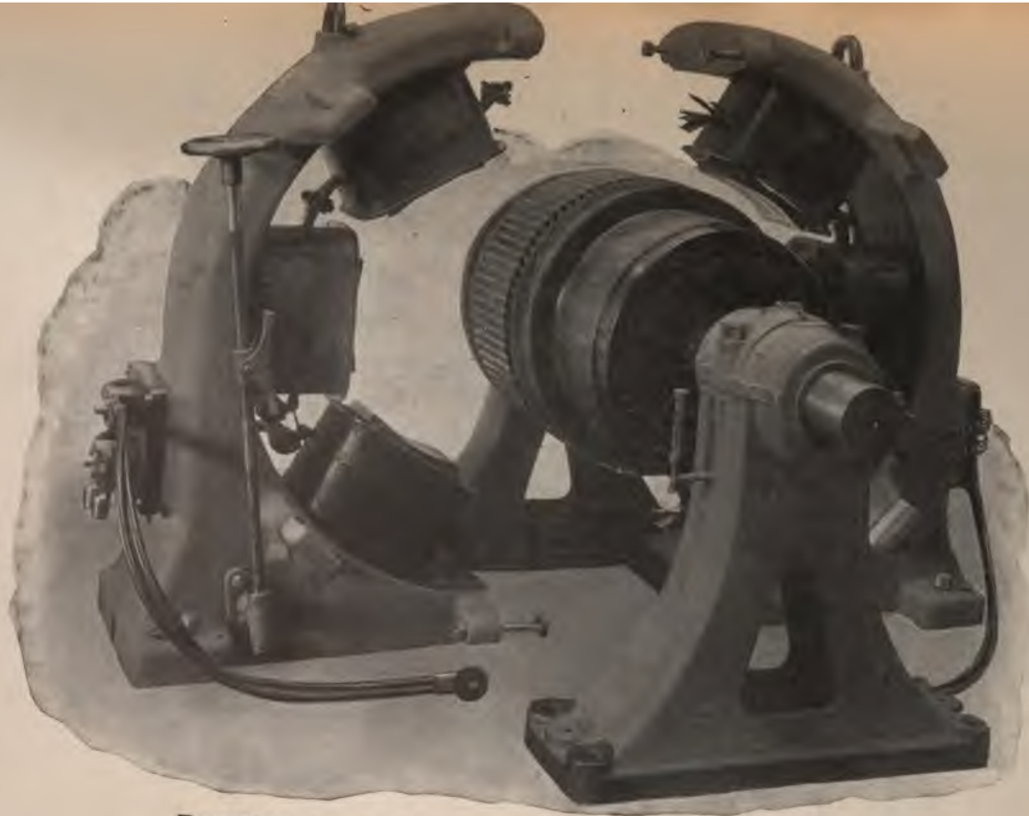
SERIES DYNAMOS IN SERIES

Fig. 29.

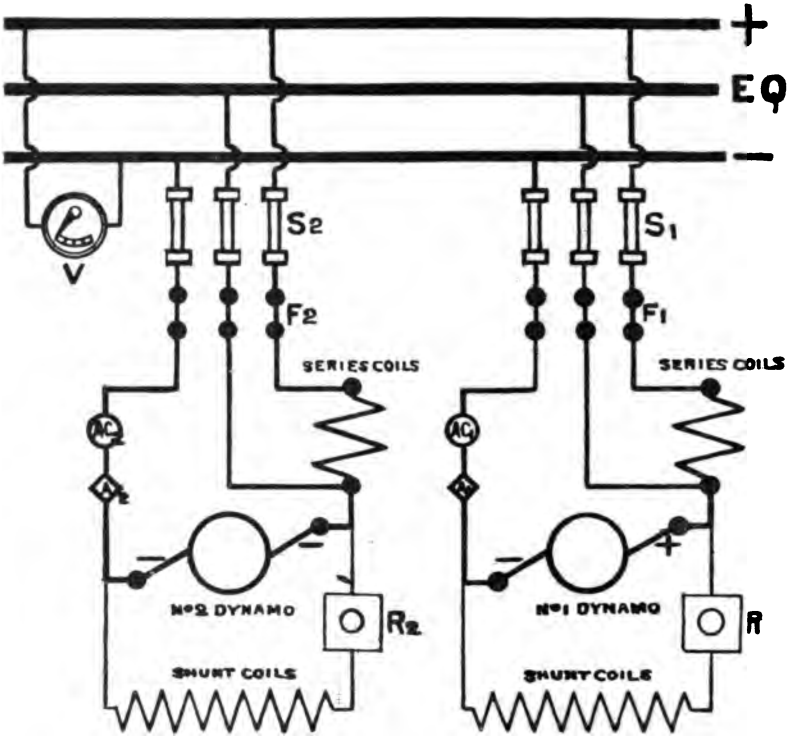


SERIES DYNAMOS IN PARALLEL

Fig. 30.

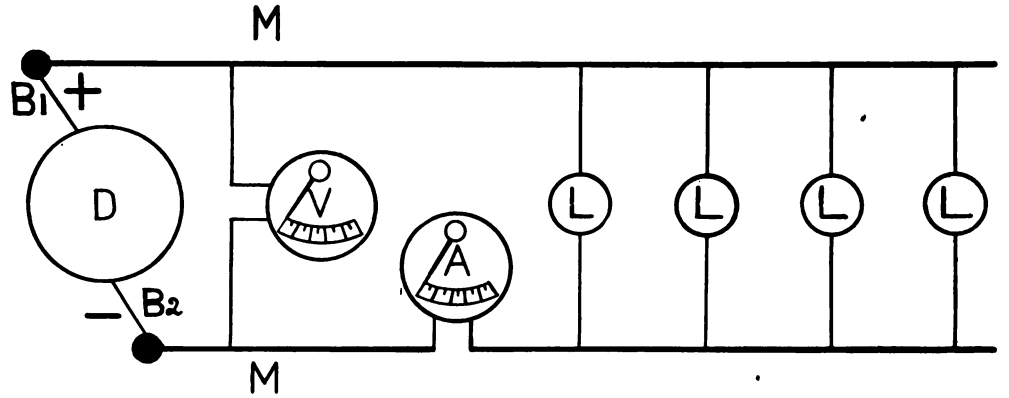


Type of Compound Dynamo, Showing Fields and Armature.
Fig. 31.



COMPOUND DYNAMOS IN PARALLEL

Fig. 32.



Connection of Ammeter & Voltmeter.

Fig. 33.

CHAPTER X.

INCINERATORS COMBINED WITH ELECTRICITY AND WATER WORKS.

Incineration can never become a success in this country until the waste heat from a properly constructed furnace is utilized for some useful power or heating purpose. Not to so utilize this waste heat, is to lose the principal advantage of incineration over all other systems of garbage disposal and to reduce it to as primitive a method of garbage disposal as dumping and as costly as reduction. In a properly constructed incinerating furnace, a temperature of 2000 degrees F. can be constantly maintained, the gases leaving the furnace at a temperature not less than 1500 degrees, which is the average temperature maintained in a boiler furnace, and to waste this heat up the chimney is to burn up money. In the modern incinerating plant, steam boilers are installed between the incinerator and the chimney, and this waste heat made to pass under them before being allowed to escape into the atmosphere, thereby not only making this heat do useful work, but removing from the gases in their long travel all dust and noxious odors before being allowed to escape. This heat is as constant as that obtained from coal-fired furnaces under boilers, and just as high a steam pressure can therefore be maintained in the boilers. As incinerating plants are operated continuously throughout the twenty-four hours, their heavier work being at night when the garbage can be delivered with less objection than

during the day, it makes their combination with electric lighting plants especially advantageous. The great economy of such a combination can be seen at a glance, as the waste heat which would be otherwise wasted is made to operate the electric plant without one cent additional cost. Such a combination as above described is no longer an experiment, for there are now successfully operating in England alone, over sixty such plants, while there has been recently installed in New York City, an electric plant in combination with their incinerating plant, which is furnishing lights for the new Williamsburg Bridge and the surrounding district. In Liverpool, where there are four incinerator installations located in different sections of the city, the waste heat from 300 tons of refuse is utilized for traction purposes, while in London the resultant power from 800 tons of refuse is used for electric lighting.

From this can be seen the enormous waste of power in our larger cities. In the City of St. Louis alone it can be safely said that 3200 h. p. is thus daily wasted.

Comparative statement showing the number of electrical units generated per ton of refuse destroyed at twenty combined electricity and destructor works in England:—

TOWN.	TYPE OF BOILER	Average Number of Units Generated per Ton of Refuse Destroyed.	Average Weight of Refuse Destroyed Daily in Tons.
Accrington	Lancashire	25	60
Bangor	Hornsby	20	9
Cleckheaton	Lancashire	35	12

TOWN.	TYPE OF BOILER	Average Number of Units Generated per Ton of Refuse Destroyed.	Average Weight of Refuse Destroyed Daily in Tons.
Colne	Babcock	20	18
Darwen	Lancashire	33	35
Fulham	Babcock	26-62	100
Gloucester	Babcock	35	25
Grays	Lancashire	33	8
Liverpool	Babcock	29-5	97
Llandudno	Babcock	32	15
Nelson	Lancashire	40	30
Patrick	Babcock	27	42
Rhyl	Babcock	15	16
St. Helens	Babcock	37.3	32
Shipley	Lancashire	37.8	25
Shoreditch	Babcock	20	80
Stepney	Babcock	32	165
Warrington	Babcock	80	50
Wimbledon	Babcock	45	54
Wrexham	Lancashire	38	35

ESTIMATE OF LIGHT AND POWER FROM A 150-TON INCINERATOR.

With a properly constructed incinerator using mechanical draft, 8 I. H. P. can be developed per ton of refuse burned, or 1200 I. H. P. in 24 hours from a 150-ton incinerator. This is equal to 895.2 K. W. Allowing 92 per cent efficiency and 11 per cent loss, this is equal to 603.55 K. W., or 150,889 candle power; which would

permit of 9430 lamps of 16 C. P. each, or 4716 lamps of 32 C. P. each, or 336 lamps of 2000 C. P. each.

With coal at $2.00 per ton and allowing 10 cents per ton for labor, the cost of incineration per ton of refuse should not exceed 19 cents, making a daily cost (24 hours) of a 150-ton incinerator $28.50, i. e., $1.19 per hour.

Burning 6.25 tons of refuse per hour, would generate 50 H. P. per hour, or 37.3 K. W., costing $1.19 or 3.2 cents per K. W., requiring nothing for the cost of the incineration, or $28.50 per day for the incineration, which would give the above output of electric current at not one cent cost. With three such incinerating plants in a city of six hundred thousand inhabitants, all public buildings and the principal business streets could be lighted at no expense whatever. Should the city have a term contract for its lighting with some company, then these lights could be distributed through the parks and other public places to beautify the city. Light is the best protection that can be given the public, better even than the most efficient police force, then, why not collect and utilize all refuse for this purpose.

While it is true that the calorific value of different refuse will vary greatly, this is no serious objection, as that of coal also varies greatly. No city should be misled by statements that the garbage can be burned by itself alone. During the summer months when the garbage will run 80 per cent moisture, at least 90 lbs. of coal to every ton of garbage must be burned; in fact, it would be safe to estimate that an average of this amount of coal per ton of refuse burned will be required throughout the entire year.

Refuse at its best is a very poor fuel, but it has its value, and this value is sufficient to make a plant operated from its waste heat at least self-supporting, which would mean a saving of thousands of dollars to every American city, besides affording a sanitary and economical method of garbage disposal.

What has been said as to combining electrical works with an incinerator, applies with equal advantages to such a combination with water works, especially in the smaller towns. There is only one exception and that is when operated in connection with water works, a greater precaution must be taken, in order to prevent any contamination from the refuse. This can be secured by a little care, and using closing doors where the refuse is discharged.

LABOR.

As over 50 per cent of the total cost of disposing of refuse is for labor, it is evidently a most important factor, but one which in this country has been given but slight attention, owing to the mistaken belief that any class of labor could do this character of work. No greater mistake can be made than to employ unskilled labor for refuse destruction. Should the incinerator be operated as such alone, without a power or heat combination, there still remains the most difficult work connected with proper incineration, viz.: the clinkering of the furnace. Upon this being properly done depends the character of the clinker and its sale. With proper clinkering in a high temperature furnace, the clinker is removed hard and vitreous, and finds at all times a ready sale for mortar, street or paving work.

If improperly clinkered, it is removed soft and full of foul odors, making it not only a nuisance, but its removal

a source of expense, as it being worthless it then must be hauled away.

When one considers how few good firemen can be had for coal-fired furnaces, and how easily coal is stoked in comparison with the clinker formed in an incinerating furnace, there can be no question but that only skilled firemen can be used successfully for this work.

When the incinerator is operated in combination with a heating, electrical or water works plant, the necessity of skilled labor is still more obvious. In such an incinerating plant not only should skilled engineers and firemen alone be employed, but the chief engineer should be a man capable not only of successfully operating the steam plant, but also the incinerating furnaces under him, and seeing that the entire plant is maintained at its highest efficiency.

Irrespective of the make of the incinerator used, or whether operated alone or in combination, only skilled and well paid labor can be employed with profit.

COST OF INSTALLATION AND ESTIMATED OPERATING EXPENSE OF A 300-ARC LIGHT PLANT, 150 K. W.

Lamps 500 watts, on every night, all night.
Efficiency of dynamo and engine, 87%.
Efficiency of transformer, 95%.
1 lb. coal evaporates 7½ lbs. water.
26 lbs. steam develops 1 h. p.
Requires 242 h. p. 4410 hrs. per year.

Cost of plant, $80.000.

ESTIMATE OPERATING EXPENSES.

1,856 tons coal at $2.00	$3,712.00
Removal of ashes	175.00
Water	300.00
Carbons and globes	1,000.00
Oil, etc.	600.00
2 engineers at $100 per mo	2,400.00
2 firemen at $60 per month	1,440.00
1 lineman	720.00
1 lineman, cash	300.00
Interest 4% on $80,000	3,200.00
Depreciation and replacement 5% on $55,000	2,750.00
Depreciation and replacement 10% on $25,000	2,500.00
Insurance 1% on $55,000	550.00
	$19,647.00

COST LAMP, $65.50.

If 1 lb. coal evaporates only 5 lbs water.
Total cost $21,581.00

COST LAMP, $72.00.

By combining this plant with an incinerating plant, the sum of $6,112.00 can be annually saved in the expense of coal and labor alone, which is about 33 per cent of the total operating expenses of the plant.

CHAPTER XI.

INCINERATOR SITE AND BUILDINGS.

Next in importance to the selection of the proper method of disposing of the refuse, is the question of the location of the plant to be used for that purpose. This is not only a question affecting the health of a community, but one of special interest to the taxpayer who must pay the cost of long and useless hauls to such a plant, should it be improperly located. Should incineration be adopted as the method of disposal, a long haul to a plant located at or near the city limits is not only an unnecessary expense, but a positive menace to health of the residents of the streets through which it is hauled.

With a properly constructed incinerating furnace, there is no possibility of the escape of noxious odors or objectionable smoke, for there must be complete combustion. The plant itself would be less objectionable than a steam power plant similarly located, for not only is there an absence of all smoke, but also of the noises which usually accompany a manufacturing plant.

By locating the incinerating plant in the central section of the city, not only is the great expense of the long hauls avoided, but the unsanitary feature of hauling the dripping garbage for a long distance through the streets removed. No time should be lost in the rapid disposal of the garbage after its collection, for it is during this period of time that it becomes most objectionable, both to the senses and to health. Its value for reduction purposes also depends on dispatch in its handling.

It costs the city of St. Louis $70,000 annually to dispose of its 70,000 tons of garbage and $116,900 to collect same, this being about the average cost for the collection and disposal of garbage in the different cities of this country.

This cost of $1.67 per ton for the collection of the garbage is due to the long hauls necessary under the present system. Should there be three incinerators located in central sections of the city, this cost of collection could be reduced at least 75 per cent.

It has been repeatedly demonstrated that a well constructed incinerator is entirely unobjectionable. No less than 94 per cent of all the incinerators in Great Britian are located in or near the central sections of its cities, and in the city of Sheerness, the combined incinerator and water works plant is located only 8 feet from their principal school. By locating the incinerator in a central section of the city its waste heat can be utilized for useful work, such as for electric lighting, and thereby make it a self-supporting method of garbage disposal, instead of the enormously expensive methods now adopted by all American cities.

While a properly constructed incinerating plant can never become objectionable, on the contrary, it is impossible to operate a reduction plant without it being a nuisance.

I have seen garbage cooked for days under a steam pressure of 175 pounds to the square inch in the latest and most improved form of digesters and at the end of this time the odors were as foul, or worse, than at first. These odors can only be destroyed by subjecting them to a furnace temperature of at least 1500 degrees F. and to do this would require an incinerator operated in conjunc-

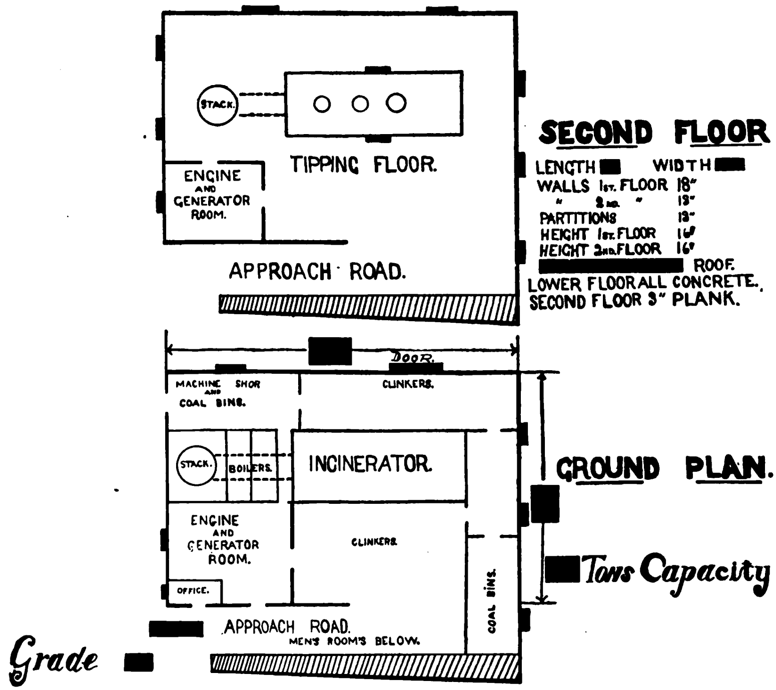
tion with every reduction plant. The prompt collection and delivery of garbage would decrease this nuisance to a great extent.

While admitting the value of the reduction process for that portion of the refuse which can be utilized at a profit, which is about 23 per cent, there can be no denying the fact that the best location for any reduction plant is just as far from the residence of any citizen as it is possible to get it. As dead animals and kitchen garbage constitutes this 23 per cent of refuse for reduction, the necessary accumulation of this refuse at the plant while being sorted and made ready for the digesters, etc., is most offensive and unsanitary. For a city of six to seven hundred thousand inhabitants, there should at least be three incinerating plants, located in different sections of the city and easy of access, and one reduction plant located at or near the city limits, which can be reached without requiring the refuse to be hauled through the principal streets of the city.

INCINERATOR BUILDINGS.

The building should be two stories in height, and constructed of the best building brick throughout, with either a slate or steel roof, properly supported by steel I beams and cinder fire-proof throughout. The walls of the first floor should be 18 inches in thickness, and of the second floor 13 inches in thickness. All partitions should be of brick and 13 inches in thickness.

All of the lower floor should be of the best concrete, and the second floor laid with 3-inch plank. The height of the first and second floors should be 16 feet.



BRANCH GARBAGE INCINERATOR

BRICK ENCLOSURE FOR SAME.

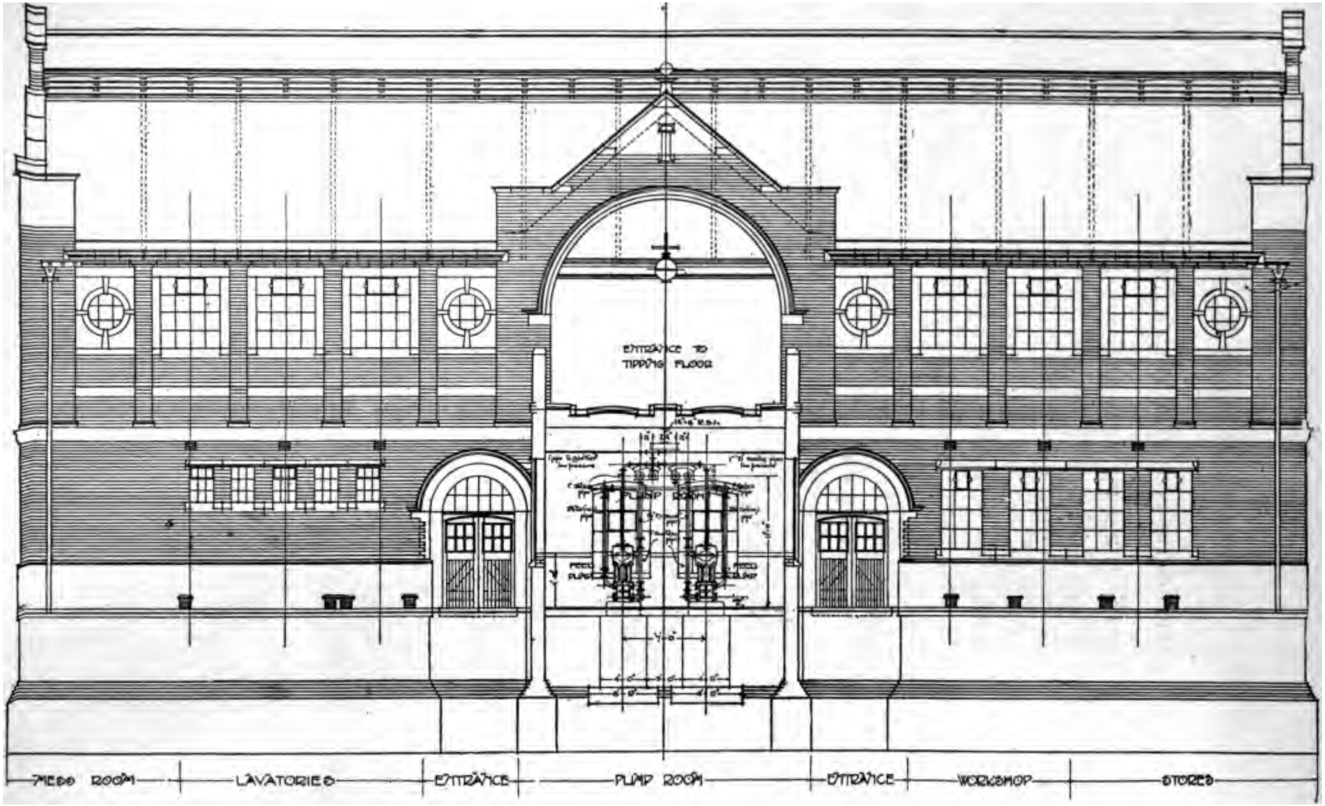
Fig. 34.

APPROACH ROADWAY TO BUILDING.

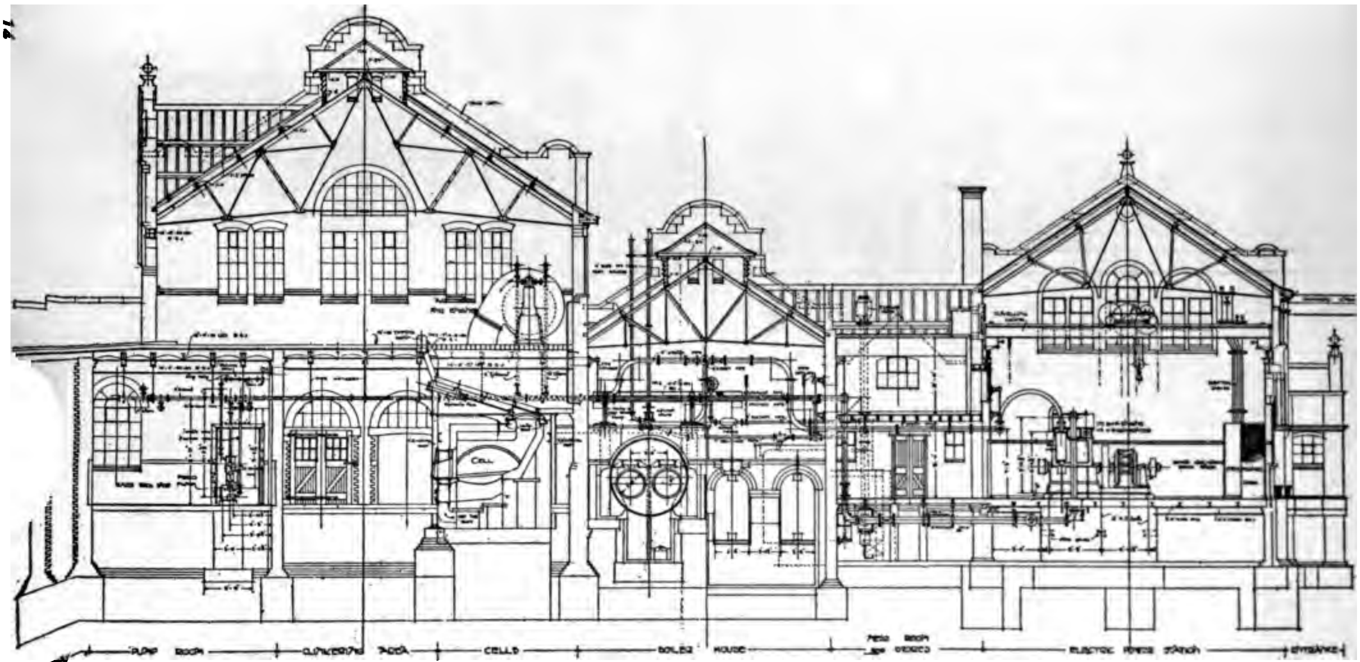
The approach roadway to second floor should be not more than 20 per cent grade, and 12 feet in width, with the retaining walls of the best hard brick, laid on solid rock foundation and supported by steel I beams, with the best fire-proofing to be used between the beams. The roadway to be laid with vitrified paving brick, or granite blocks.

The building should be of ample dimensions to permit of future power installations. For a 50 or 80-ton incinerator, the building should be at least 56 feet in length and 40 feet in width.

Figs. 34, 35 and 36 show plans of building suitable for the Branch and other Incinerators.



Front Elevation of Incineration Building.



Cross section of Incinerator Building, Boiler House and Engine Room.

Fig. 36.

CHAPTER XII.

NATURAL AND MECHANICAL DRAFT.

The maintenance of proper draft at all times, irrespective of the nature or quantity of the furnace charge, or the atmospheric conditions, is the first and most essential requirement for the successful incineration of garbage.

Without sufficient draft, under positive and flexible control, the high furnace temperature necessary for the complete incineration of garbage, cannot be obtained, and if obtained could not be maintained.

Combustion in all furnaces, is simply the combination of the elements carbon and hydrogen in the garbage or fuel used, with the oxygen in the air.

The supply of air is furnished by the draft, and the draft is produced either by natural or mechanical means.

A NATURAL DRAFT is produced by a stack or chimney, while a mechanical draft is produced by mechanical means, such as a blower, a fan, or a steam jet. The draft produced by a blower or steam jet is called a FORCED OR PLENUM draft, while that produced by a fan is an INDUCED OR VACUUM DRAFT.

The natural draft is the oldest and the most primitive method of producing a draft, but for a garbage incinerator it is insufficient and unsuitable. The constructors of American incinerators alone have employed this method for obtaining a draft, and it is partially due to this fact that there has been such a great number of failures in this country.

Of the 200 incinerators in successful operation in other countries, not one uses other than a mechanical draft, either forced or induced.

The reason for this is apparent when you consider that 1,700 pounds of every ton of garbage consumed is water, and of such character that unless the furnace temperature is maintained at a minimum of 1,500 degrees the garbage cakes, and will choke any draft obtained by natural means. Again, unless almost perfect combustion is maintained the temperature of the furnace quickly falls to a point where perfect incineration will no longer take place, thus permitting noxious odors to escape unconsumed.

In order to obtain sufficient draft to maintain the desired temperature of 2,000 degrees, it becomes necessary to increase the height of the chimney, and in so doing from 20 to 40 per cent of the heat of the fuel is dissipated in the atmosphere without useful effect.

Any attempt to utilize a portion of this waste heat necessarily reduces the temperature, and lessens the draft, for draft is produced by the difference of heated air in the chimney and cooler air outside, that is the unbalanced pressure between the two.

A chimney of excessive height would afford no relief, for a draft so produced is neither positive nor flexible, as is necessary for the consuming of fuel the nature of the ordinary garbage.

A high chimney also entails considerable expense for its erection, in addition to this continual waste of useful heat.

As compared with this insufficient and wasteful process of air movement, an induction fan calls for an expenditure of only about one-fourth of the heat required for the chimney in order to produce the same results.

With a mechanical draft the temperature of the furnace is always under control, and without waste of heat. Such a draft is both positive and flexible, and with it can be obtained and maintained almost perfect combustion, which means that all useful heat is utilized, and the complete absence of all smoke and smell.

The standard test for determining the efficiency of combustion is the test for CO2 (Carbonic oxide). The more perfect the combustion, the higher being the percentage of this gas. With 2 per cent only of CO2 in the gases of combustion, the loss of heat would be as high as 60 per cent, due to the heat being absorbed by the excessive amount of the cold air admitted to the furnace. With 10 per cent of CO2, the loss of heat is reduced to 15 per cent, while with 15 per cent of CO2, the loss becomes only about 10 per cent.

On the contrary, the greater the per cent of CO (Carbon Monoxide), the more imperfect the combustion, due to the lack of sufficient air. The following tests show how perfect is the combustion with a mechanical draft:

STEAM JET BLOWER DRAUGHT.

Table showing percentage of CO2 in the gases of combustion:—

Town.	Rate of Combustion.	Ashpit Pressure.	Average % CO2.	Average % Oxygen.
Oldham	....29 lbs.	1 1-6 in.	5 samples	
			8.60	10.90
			15.50	3.90
			18.10	1.40
			8.50	10.70
			13.30	6.30
Rochdale	...50 lbs.	1⅛ in.	18.90	..96
			17.36	1.90

Town.	Rate of Combustion.	Ashpit Pressure.	Average % CO2.	Average % Oxygen.
Lancaster	..59½ lbs.	1.75 in.	15.5	.....
Nelson	.....29 lbs.	1.50 in.	13.16	.....
	68½ lbs.	2⅝ in.	14.40	.....
	57 lbs.	1.85 in.	(30 readings)	
			12.21	.....
Hereford	...54.88 lbs.	1.45 in.	15.56	(20 readings)
			14.92	5.40
			16.84	(16 readings)
	51.52 lbs.	1.37 in.	16.83	3.54
			16.27	(14 readings)
	54.75 lbs.	1.82 in.	16.38	3.74

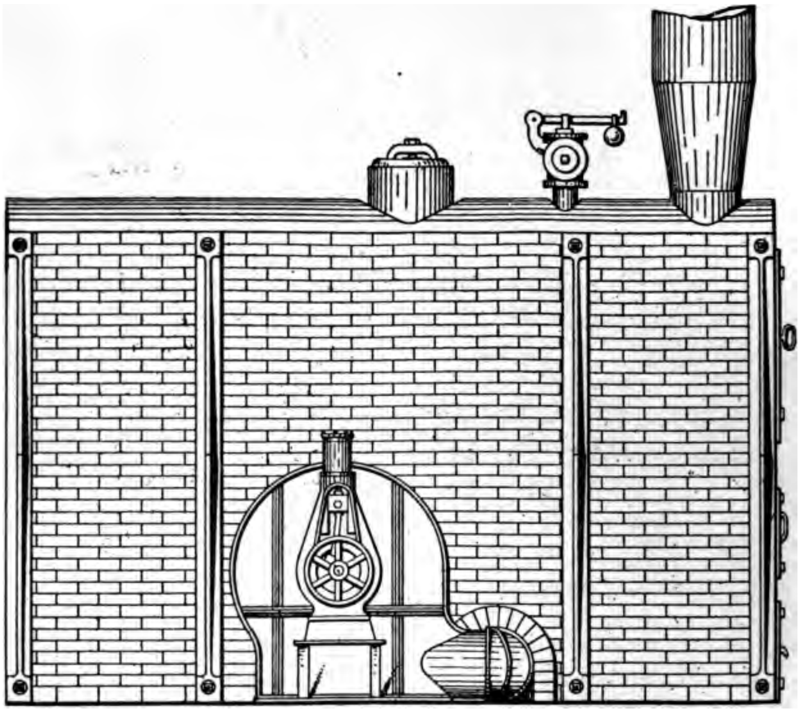
FAN DRAUGHT.

Table showing percentage of CO_2 in the gases of combustion:

Town.	Rate of Combustion per sq. ft.	Average Ashpit Pressure of Water.	Average % of CO2.	Average % of Oxygen.
St. Helens	....103 lbs.	3.1 in.	(21 readings) 10.4	(20 readings) 9.16
Blackburn	... 34.66 lbs.		11.87	.....
Warrington	.. 59 lbs.	2 in.	7.2	11.8
Metropolitan Borough of Wandsworth	68.4 lbs.	2.55 in.	7.93	12.25

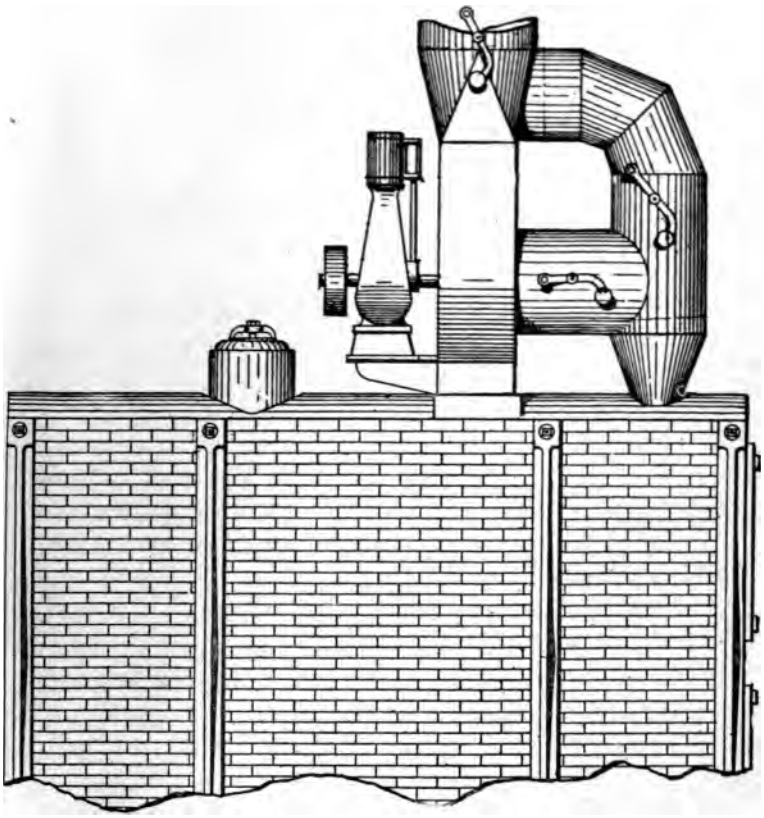
One of the requirements of constructors of incinerators should be that an analysis of the chimney gases should show at least 15 per cent CO_2 and not a trace of CO, for it is only with such a high state of combustion can incineration be made either financially satisfactory to the city, or unobjectionable to the citizens.

All incinerators should be equipped both with steam jets or blower, for a forced draft, and duplex fans for an induced draft, but of the two, the induced draft is by far the most essential and effective. With the forced draft



Blower, Forced Draft System.

Fig. 37.



Induced Draft System.

Fig. 38.

the air is *forced* through the fires from the closed ash pit, while with an induced draft, it is *drawn* through the fires by creating a vacuum over the fires. In the induced system the exhaust fan is used in place of the chimney, or supplementary to it, the products of combustion being drawn into the fan and exhausted into the chimney, which needs to be merely high enough to carry the smoke and gases clear of the roof of the building. The fan itself maintains the partial vacuum that would exist with a chimney of suitable height. Figs. 37 and 38 show these two systems in operation.

With this system the maximum intensity of the draft obtainable is greater and permits a much wider range regulation than with the forced-draft system. The leakage of air is also inward, thus avoiding the constant outward leakage, as in the forced-draft system.

The induced-draft system offers the additional advantage that the supply of air above the fire can be nicely adjusted to secure more perfect combustion. While the maximum intensity of the draft of the chimney is largely dependent upon atmospheric conditions, as well as height, the intensity of the draft when produced mechanically is limited only by the speed of the fan, which can be made to cover a wide range of conditions.

When regenerators for heating the air for combination, or economizers, are used in connection with the incinerator or boilers, mechanical draft then becomes almost a necessity to provide some means of furnishing sufficient air for combustion, in order that the gases may reach the chimney at a sufficiently high temperature to produce a draft. When a forced draft alone is used with a chimney, the forced draft and the chimney pull should be so regulated that a perfect balance of the gases is main-

tained. When such a condition exists no cold air can be drawn into the furnace, even when the fire doors are left open.

The principal advantages claimed for mechanical draft are as follows:—

(1) The ability to control the rate of combustion.

(2) A close regulation of the air required for combustion, thus avoiding improper combustion.

(3) Reduction of the first cost for producing the draft required.

(4) Permits the installation of regenerators and economizers without the necessity of providing additional means for maintaining the draft.

(5) Permits an absolutely uniform draft, regardless of atmospheric conditions.

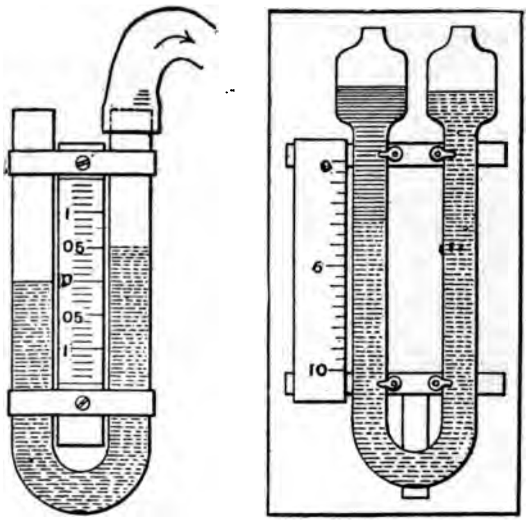
(6) For increasing the draft, where insufficient chimney capacity exists.

(7) Permits the use of highly-heated air for combustion without increasing the waste heat.

(8) With mechanical draft the draft is independent of the condition of the fire, and consequently a banked fire can be started up quickly. With a natural draft, the intensity of the draft depends on the intensity of the fire, and is therefore least when the fire is low and draft is most needed.

DRAFT WATER GAUGE.

The intensity of the draft is measured by means of a water gauge, as shown in Fig. 39. The gauge consists of a glass tube open at both ends, bent to the shape of the letter U. To use the gauge, the left leg is connected with the chimney and the right leg left open to the outside air. The air outside of the chimney being heavier, it presses on



Draft Gages.

Fig. 39.

the surface of the water in this leg and forces some of it up higher in the left leg. The difference in the two water levels in the legs, represents the intensity of the draft, which is expressed not in ounces, but in inches.

Wood requires about one-half inch of draft; bituminous coal requires less draft than anthracite. To burn anthracite or slack coal requires about one and one-fourth inches of draft. Two inches is about as much draft as can be obtained with a natural draft, but with a mechanical draft, five inches, if necessary, can be easily obtained, the rate at which it is necessary to run the fan depending upon the temperature of the heated gases.

HOT AIR FOR COMBUSTION.

Owing to the moist nature of garbage, 70 to 80 per cent being water, and the great absorbent properties of heated air, no incinerator fills the modern requirements unless all air which is forced into the furnace for combustion is first heated by some economical means:

This is usually done in English destructors by utilizing the heated gases for this purpose, after they have left the boiler and before entering the stack. These heated gases are passed through a nest of iron pipes, and the cold air which is used for combustion is made to circulate around these pipes as it passes to the furnace. This is done by the use of an induced draft, using steam jets to draw the heated air through a conduit, which connects direct with the ash pit, from which the air is forced through the fires with a blower.

RETENTION OF DUST.

As the weight of the dust produced forms about 5 per cent. of the total weight of the garbage consumed, all

constructors should be required to specify the method adopted by them to prevent the escape of this dust from the stack. Should no method be provided, in addition to the nuisance which will result, the heating surface of the boiler will be reduced, and the draft materially suffer. The flues of the boiler should be large, never less than 6 inches, which will assist in causing a low velocity of travel in the flues, and a dust-catcher or collecting chamber be provided between the incinerator and boiler, so as to prevent as much as possible this dust entering the boiler.

The earlier this dust is deposited the better, and any form of combustion chamber, dust-catcher or collecting chamber which secures this result should be satisfactory.

Such chambers can be very simple of construction, one of the most successful forms being in use at the Taunton plant in England. It consists simply of two annular chambers, one smaller and enclosed in the larger. The gases enter the outer chamber and circulate around it, thereby throwing the dust against the outer wall and thence enter the inner chamber through an opening in the top of same and flowing downward to escape into the chimney. Cleaning doors are provided for removing the dust which accumulates.

I have taken the Rochdale destructor as a model plant of efficiency and economy. As can be seen from the following analyses of the chimney gases, the percentage of CO2 is extremely high, while not a trace of CO is shown.

ROCHDALE DESTRUCTOR.

ROCHDALE, ENGLAND. Population, 83,114

Tests Made at the Corporation Sanitary Works.

CO NIL.

(W. F. Goodrich's "Refuse Disposal.")

Date of test	Mar. 1,'95.	Nov. 14,'95.	Nov. 15,'95
Duration of test	6 hours	6½ hours	6½ hours
Total refuse destroyed	11.4 tons	13.75 tons	14.3 tons
Refuse burnt per hour	4,256 lbs.	4,738 lbs.	4.945 lbs.
Refuse burnt per hour, per sq. ft. of grate	47.3 lbs	52.6 lbs.	54.9 lbs.
Water evaporated per lb. of refuse	1.64 lbs.	1.39 lbs.	1.47 lbs.
Equivalent evaporation, from and at 212 degrees	1.97 lbs.	1.68 lbs.	1.78 lbs.
Number of boilers used	Two	One	One
Temperature of feed water	53° F.	52° F.	52° F.
Total water evaporated	42,072 lbs.	42,900 lbs.	47,400 lbs.
Water evaporated per hour	7,012 lbs.	6,600 lbs.	7,290 lbs.
Equivalent evap. from and at 212 degrees F	8,431 lbs.	7,980 lbs.	8,820 lbs.
Average steam pressure per sq. inch	113 lbs.	113 lbs.	114 lbs.
Percentage of (CO_2) in products of combustion	15.9 lbs.		
Percentage of free oxygen	2.2 lbs.		
Labor cost per ton of refuse destroyed	7½ d.		

COMPARISON OF COSTS—FIXED CHARGES FOR CHIMNEY AND INDUCED DRAFT.

(Walter B. Snow.)

Method of Draft Production	First Cost Amount	First Cost Ratio	Annual Fixed Charges Amount	Annual Fixed Charges Ratio
Chimney	$10,000	1.00	$800	1.00
Induced Draft Plant (2 fans)	4,200	.42	462	.58
Induced Draft Plant (1 fan)	2,670	.267	294	.37
Forced Draft Plant (1 fan)	1,870	.187	206	.26

RELATIVE COSTS OF BOILER PLANT, WITH CHIMNEY AND MECHANICAL DRAFT.

12 Boilers	$37,000
2 Economizers	10,500
Boiler and economizer settings and by-passes	9,000
Automatic damper regulators and dampers	400
Chimney, including foundations	10,700
Boiler house	11,500
Total	$79,100

RELATIVE COSTS.

Chimney Draft.		Mechanical Draft.	
Cost of chimney	$10,700	Cost of mechanical draft plant, complete	$4,700
Cost of damper regulators and dampers	400	Saving by using mechanical draft	6,400
Total	$11,100	Total	$11,100

The costs of the chimney and the mechanical-draft apparatus, which are also indicated, show a saving in first cost of $6,400, as the result of using the mechanical-draft method.

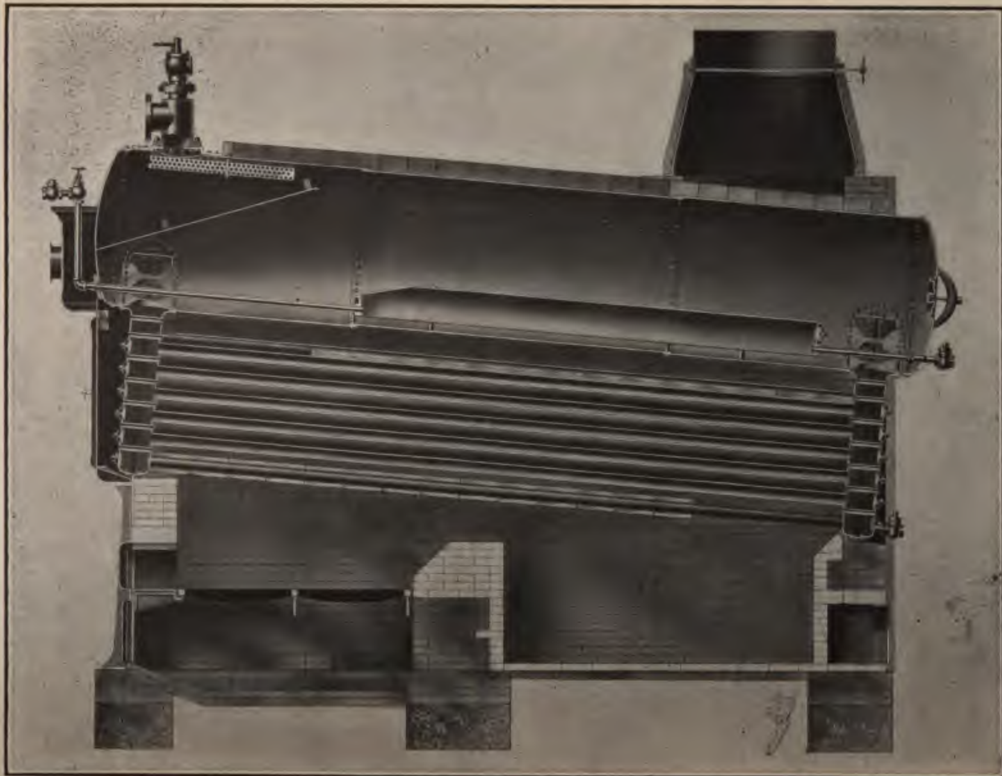
INFORMATION REQUIRED FOR ESTIMATE UPON MECHANICAL DRAFT APPARATUS.

Total number of boilers....Type of boilers........... Total square feet of grate surface........ Total square feet of heating surface...........

Dimensions of Boilers: No. of each size .... Diameter .... Length of tubes .... No. of tubes .... Diameter of tubes ....

Rated horse-power of plan....H. P. present output... H. P. desired output....H. P. steam pressure......lbs. Rate of combustion per sq. ft. of grate per hour......lbs. Kind of fuel to be burned........Total amount to be burned per hour......lbs. Size of present chimney.

Height .... ft. Internal dimensions......inches. Type of grate..............Percentage of free area through grate......Kind of stoker, if any is used............ Kind and size of economizer, if any is used............ Intensity of draft at base of chimney....inches of water. Temp. of escaping gases....degs. F. Is this estimate for a proposed or an existing plant?...................... If for any interval the above conditions are exceeded, state for how long and how much.



Type of Water Tube Boiler.

CHAPTER XIII.

THE COMPARATIVE ADVANTAGES OF VARIOUS TYPES OF STEAM BOILERS FOR INCINERATING AND CENTRAL HEATING PLANTS.

Owing to the dust which is unavoidable in all incinerating plants, a water tube boiler is preferable to the ordinary shell boiler, unless the flues of latter are at least 6 inches in diameter. With flues of this size, either style of boiler can be used to advantage.

For central heating plants water tube boilers are preferable, owing to their quick steaming qualities.

As the question of the proper selection of boilers will enter into all contracts for installing incinerating or heating plants, a few of the leading types of American boilers, with proper specifications for same, are here given with illustrations.

Fig. 40 illustrates a common type of a water-tube boiler. In such a boiler the water circulates through a series of tubes of comparatively small diameter, which communicate with each other and with a common steam chamber. The flames and hot gases are made to circulate between them and are usually forced by baffle plates to be made to act equally on all parts of the tubes before being allowed to escape up the chimney.

While there are many varieties of this type of boiler, the above description constitutes the essential principles of them all.

In the best forms of these boilers, they are suspended entirely independent of the brick-work from wrought-iron girders resting on iron columns.

The chief advantages claimed for this type of boiler are:

(1) Safety from explosions, owing to the contents of the boiler being divided up into small portions throughout the water tubes, water legs and steam drums. Should there be a rupture in the tubes, or any part of the boiler, only the immediate contents will be liberated, instead of the entire mass of water and steam.

(2) The tubes being of much smaller diameter than would be necessary if there were only a few in number, they can be made much stronger, and therefore less likely to rupture.

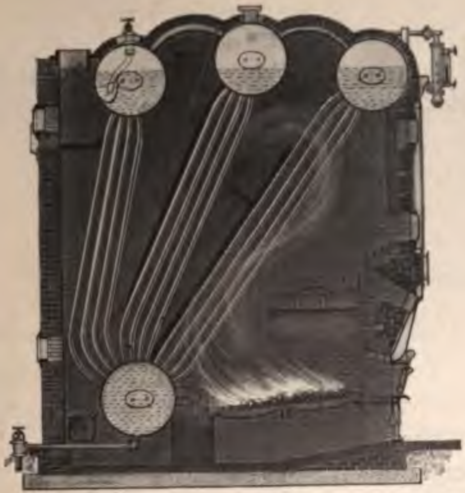
(3) Owing to their contents being held in small portions, instead of in a large mass of water, they possess quick steaming qualities.

The disadvantages of these boilers are as follows:

(1) They require more masonry for their setting, and occupy more space than shell boilers.

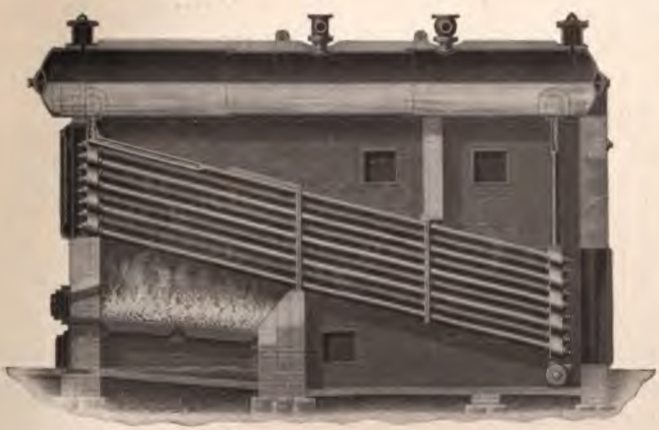
(2) Owing to the water being held in small quantities, irregular firing is apt to cause a violent generation of steam, producing sudden fluctuations of pressure, which may result in priming and thereby overheating the tubes.

(3) While this type of boiler is very susceptible for cleaning, the scale which forms in the tubes at times becomes very difficult to remove.



The Sterling Water Tube Boiler.

Fig. 41.



The Babcock & Wilcox Boiler.

Among the principal manufacturers of this type of boiler in this country, are:

The Heine Safety Boiler Co.,
The John O'Brien Boiler Works Co.,
The Erie City Iron Works Co.,
The Sterling Consolidated Boiler Co.,
The Babcock & Wilcox Boiler Co.

SHELL, OR HORIZONTAL TUBULAR BOILERS.

This is the most popular form of boiler in use, possessing many advantages over all other types, the first of which is its cheapness.

Its principal advantages are its steady steaming qualities, its durability and adaptability to any class of work.

In this type of boiler, as shown in Fig. 42, the shell is filled with small tubes or flues varying in diameter from 2 inches to 6 inches, determined by the size of the boiler and the work required, the products of combustion being made to pass through the tubes or flues, instead of around them as in the water-tube type of boiler.

The principal disadvantages of this type of boiler are:

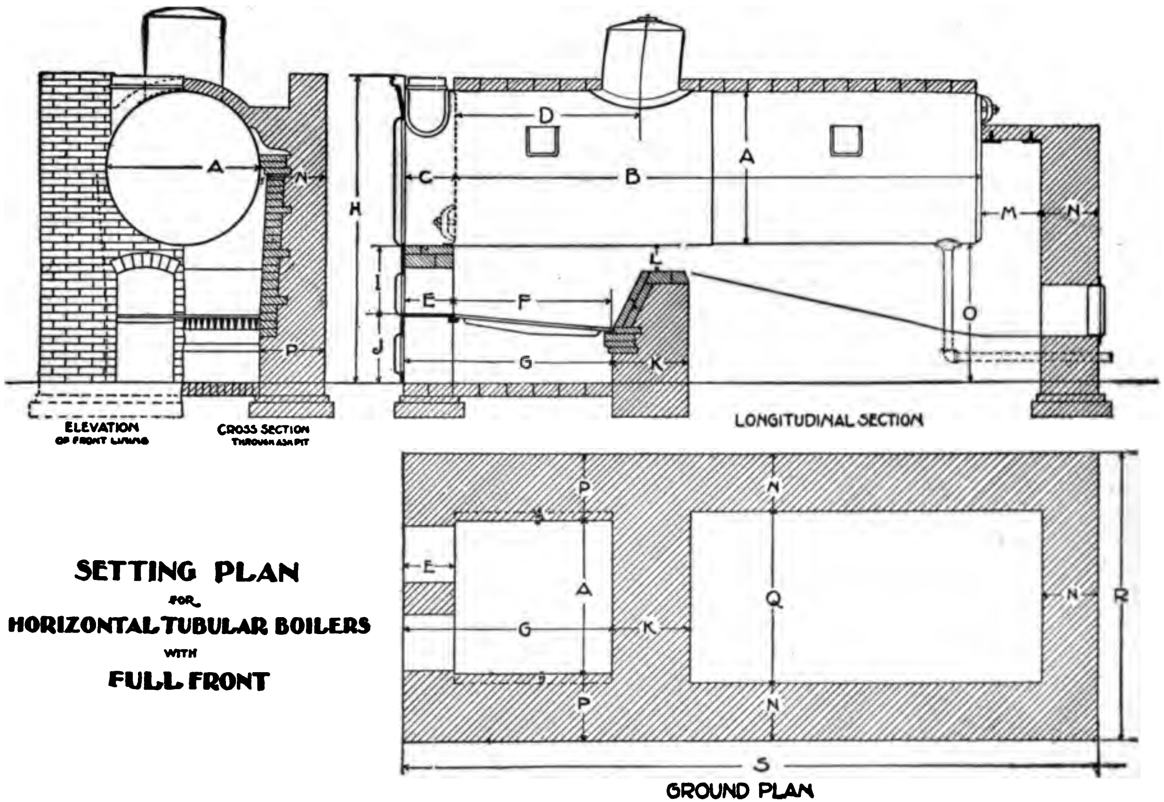
(1) Its lack of safety.

(2) Its slow steaming qualities, owing to the large body of water to be heated.

(3) The liability of the tubes or flues to rupture, owing to the large diameter necessary for same.

(4) The amount of space necessary for boiler setting.

In both of the above types of boilers the chief considerations are, proper circulation, and a sufficient length of travel of the gases before escaping up the chimney. Owing to these two types possessing these two requirements above all other types of boilers, they are recognized as the standard boilers throughout the world.



SETTING PLAN
FOR
HORIZONTAL TUBULAR BOILERS
WITH
FULL FRONT
ELEVATION
OF FRONT LINING
CROSS SECTION
THROUGH ASH PIT
LONGITUDINAL SECTION
GROUND PLAN
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S

Fig. 42.

Among the principal manufacturers of this type of boiler, are:

The Joseph F. Wangler Boiler and Sheet Iron Works,
The Kewanee Boiler Co.,
The John O'Brien Boiler Works Co.,
John Rohan & Sons Boiler Works Co.

VERTICAL TUBULAR BOILERS.

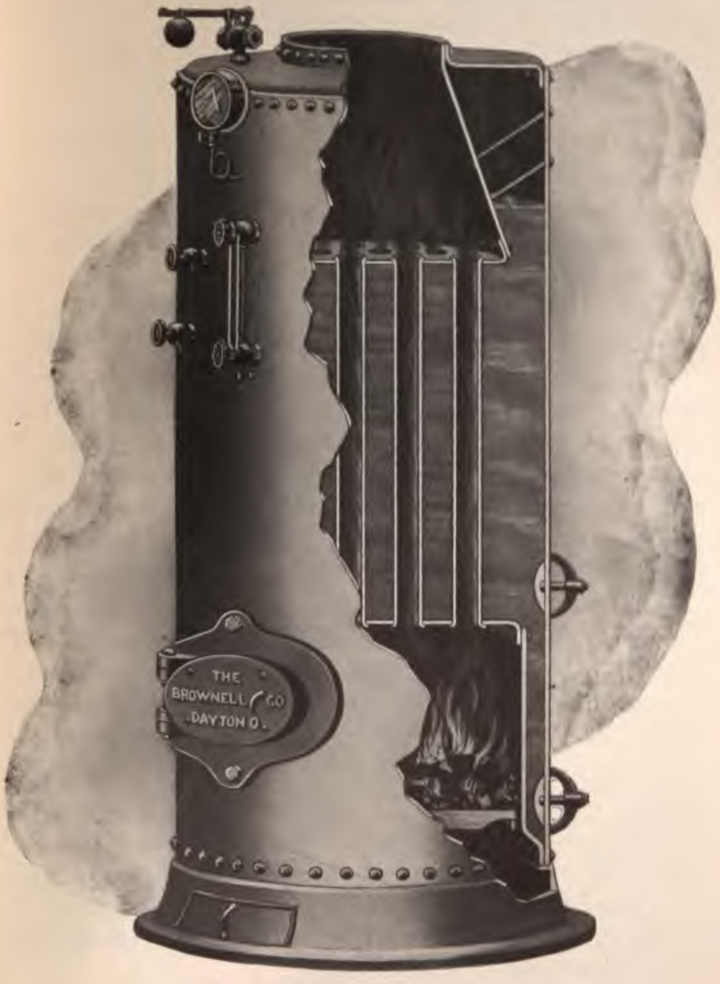
This is one of the first types of boilers used, owing to its extreme simplicity.

As shown in Fig. 43 this boiler consists of a casing or shell, cylindrical in shape, composed of steel plates riveted together. The top is made dome shape, in the center of which is placed the chimney, which is formed of the usual wrought-iron plates. The furnace, which is placed at the bottom of this shell, is entirely surrounded by water, except the bottom, in which is placed the grates. The tubes pass through the boiler, connecting the furnace with the top of the boiler. The connection of these tubes determines whether the boiler is (1) a through-tube boiler, or (2) a submerged-tube boiler. The latter type is preferable, but more expensive.

These boilers are used where floor space is valuable and there is sufficient height. While in general they are not as economical as other types of boilers, they are becoming more universally used owing to their many other good qualities.

Among their principal advantages are:

(1) Entirely self-contained.
(2) The small amount of floor space required.
(3) Ease of installation.
(4) Portable character, permitting them to be removed from one place to another with ease and dispatch.



Upright Submerged Tubular Boiler.

Fig. 43.

(5) Their extreme simplicity.

(6) Their low cost, and durability.

Their principal disadvantages are:

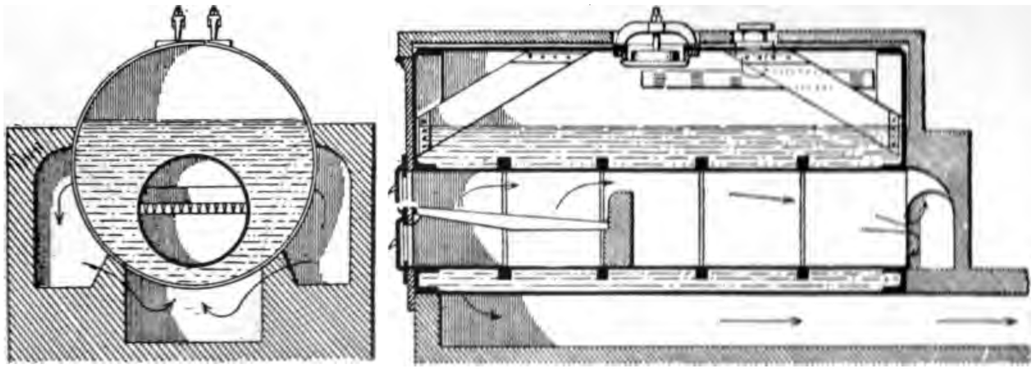
(1) Their lack of safety.

(2) Waste of fuel owing to short travel of gases, and lack of proper circulation.

While this boiler is largely manufactured throughout the country, the Brownell Engine Co. is one of the best known manufacturers.

The above three types of boilers are the standard types generally used, though there are many other types which for their particular work are equally as good, or possibly better. The character of the work required must largely determine the nature of the boiler to be used. While the safety of the boiler itself is naturally the first consideration in all types of boilers, with the modern requirements and the high class of men who are engaged in the construction of boilers, it might be said that less attention can be paid by the purchaser to this than to the many requirements which are seemingly less important. The American boiler leads all boilers in safety of construction and efficiency, and the municipality or citizen who finds it necessary to purchase a boiler, can do so with the assurance that no advantage will be taken of him by any of the leading boiler makers of this country. The safety of the public depends to a large extent upon the honor of the plate manufacturer and that of the boiler maker, for however strict inspections may be made, it is impossible to discover all hidden defects. I have never known it to be abused by them.

Figure 46 represents a type of an English boiler, which though one of the first types used, is still popular in that country, and especially so for incinerating plants.



Cornish Boiler—A Type of an English Boiler.

Fig. 46.

AVERAGE DIMENSIONS OF WATER TUBE BOILERS.

From "The Engineer."

Boiler. Horse-power	No. Tubes in Width	No. Tubes in Height	Length Tubes in Feet	Diam. of Drum. Inches	Length of Drum. Feet	Average Weight in Tons	Length of Setting. Feet	Width of Setting. Feet	Height of Setting. Feet	No. of Common Brick	No. of Fire Brick	Diam. of Safety Valve. In.	Heating Surface in Sq. Ft.	Area of Grate. Square Feet
10	3	4	6	24	10	3	9	4	8½	2200	590	2	119	5.21
12	3	4	8	24	12	3¼	11	4	8½	2620	740	2	150	6.25
15	3	5	8	24	12	3½	11	4	9	2760	790	2	181	7.28
20	3	5	10	24	15	4¼	13	4	9	3170	980	2	219	8.33
25	4	5	10	30	15	5	13	5	9½	3350	1000	2½	293	10.67
30	4	5	12	30	17	5¼	15	5	9½	3760	1170	2½	343	10.67
35	4	6	12	30	17	6	16	5½	11	5970	1510	3	401	12.00
40	4	6	14	30	19	6½	19	5½	11	7460	1680	3	460	13.33
45	4	7	14	30	19	7	19	5½	11	8630	1410	3½	526	13.33
50	4	8	14	30	19	7¼	19	5½	12	8920	1540	3½	593	13.33
65	5	8	14	36	19	8½	19	6	12½	9180	1600	3½	735	16.25
75	6	7	16	36	21	10	21	7	12	9890	1650	3½	870	19.17
85	6	8	16	36	21	11	21	7	12½	10500	1738	4	983	19.17
95	6	9	16	36	21	11½	21	7	13	10900	1950	4	1098	23.00
105	6	9	18	36	24	12	23	7	13½	12570	1970	5	1218	23.00
110	7	8	18	36	24	12¼	23	7½	13	12400	2000	5	1265	26.50
120	7	9	18	36	24	12½	23	7½	13½	12750	2010	5	1411	26.50
125	7	9	18	42	24	12¾	23	7½	14	12800	2160	5	1426	26.50
140	8	9	18	42	24	14	23	8	14	12820	2060	5	1619	30.00
150	12	7	16	36	21	18¼	21	10	12½	13160	2020	4	1741	36.67
160	9	9	18	48	24	16¾	23	8	14½	12960	2060	5	1827	33.50
175	12	8	16	36	21	18¾	21	10	13	13180	2160	4	1966	36.67
190	12	9	16	36	21	20¼	21	10	13½	13300	2200	4	2197	44.00
210	12	9	18	36	24	20¾	23	10	13½	13500	2230	5	2437	44.00
220	14	8	18	36	24	21¼	23	11½	13	13800	2310	5	2531	51.00
240	14	9	18	36	24	23¼	23	11½	13½	14000	2350	5	2823	51.00
250	14	9	18	42	24	24¼	23	11½	14	14000	3000	5	2852	51.00

Sectional View.

Type of Internal Furnace Boiler.

Fig. 44.

INTERNAL FURNACE BOILERS.

Figs. 44 and 45.

The types of the boilers heretofore described have all been external furnace boilers, that is, the furnace is outside of the boiler shell and distinct from same.

The *internal furnace* type of boiler, on the contrary, has its furnace within the boiler shell.

The chief advantage of this type of boiler for ordinary work is the economy of first cost, they being "self-contained," that is, they are independent of any masonry setting, cast iron fronts, buckstays, tie rods, etc., therefore they require but little foundation, and are susceptible of being easily removed from one location to another.

They are also capable of carrying an extremely high steam pressure and are steady steamers.

Owing to the furnaces being entirely surrounded by water, the heat of combustion is utilized to a greater extent than is practical with external furnace boilers. These boilers are extremely economical in the consumption of coal, not only for the above reasons, but owing to the absence of all brick setting, which settings usually crack and allow the heat to escape.

The principal disadvantages of this type of boiler is the short travel of the gases, thereby permitting them to escape at too high a temperature up the stack.

The circulation is also defective owing to faulty construction, and the distribution of the heating surface.

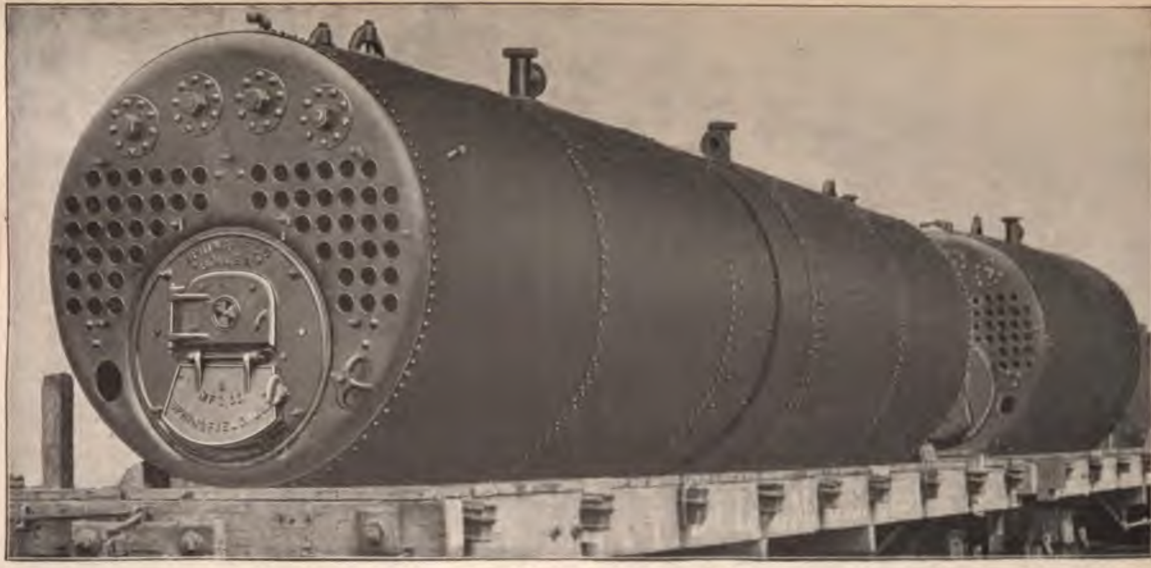
The leading manufacturers of these boilers are:

The Continental Iron Works,

Springfield Boiler and Manufacturing Co.,

Freeman & Sons Manufacturing Co.,

Rhemmeli-Dawley Manufacturing Co.



Springfield Internal Furnace Boiler.

Fig. 45.

SPECIFICATIONS FOR A SAFETY WATER TUBE BOILER.

NUMBER, TYPE AND SIZE.

There shall be ...... boiler.. of the horizontal inclined water tube type, rated at ...... horse power; the term horse power being understood to mean 30 pounds of water evaporated per hour from feed water having a temperature of 100 degrees Fahrenheit into steam at 70 lbs. gauge pressure.

GENERAL DESCRIPTION.

The boiler in all its main parts is to be composed of plate steel. It is to consist of two water legs of equal size, approximately rectangular in shape; joined together by means of a series of vertical and horizontal staggered rows of tubes, and ...... overhead circulating steam and water drum... The drum.. and tubes are to be made parallel to each other, and the water legs made perpendicular to both. When boiler is erected, same must incline towards the rear a distance of 1 inch per lineal foot.

PLATES.

All plates used in the construction of ...... boilers.. are to be of the best open hearth homogeneous flange steel, having a tensile strength of 60,000 pounds per square inch of section. These plates are to be plainly stamped with the name of the manufacturer, the tensile strength and the quality; said stamps to be so located as to be easily visible after the boiler.. has been completed.

The thicknesses required for these plates are given under the various paragraphs relating to the specific parts of the boiler herein described.

TUBES.

...... boiler is to contain .... tubes, each having an outside diameter of 3½ inches, and a length of ...... feet. Each tube is to be of the best lap-welded quality standard gauge in thickness, and made of .... The ends of all tubes are to be thoroughly expanded into the tube plates of the water legs.

The distance from center to center horizontally of the tubes is to be 7¼ inches, and the distance vertically is to be 5 inches, except that between the bottom row and the next row above, which is to be 8½ inches, so as to permit the introduction of a course of tile on top of the lower row.

WATER LEGS.

...... boiler is to be furnished with two water legs, each consisting of a tube plate, and a hand hole plate joined together by means of a strap riveted around the outside. These plates are to be so arranged as to leave a clear space of 10 inches between them on the inside.

The hand hole plate of each water leg is to be furnished with a series of oval hand holes, each measuring 3⅝ inches by 4¾ inches in size, and furnished with a heavy cast iron cover plate, one four-prong arch, one bolt and a lead gasket. A hand hole is located directly in front of each end of each tube so as to permit easy access for cleaning.

The water leg plates are to be thoroughly stay-bolted together by means of hollow stays, each having a minimum outside diameter of 1 9-16 inches, spaced a distance of 7¼ inches center to center horizontally, 5 inches center to center vertically.

CASTINGS.

...... boiler is to be furnished with one standard type water tube boiler front, a sufficient number of cast iron grate bars for covering a width of ...... inches, and a length of ...... inches, one back grate bearing bar, two (2) soot doors and frames, one set of back wall supporting plates, and one set of saddles for locating underneath the rear water leg.

BOILER SUPPORTS.

The front water leg is intended to be supported by means of cast iron columns located in the lower section of the boiler front, and the rear water leg by means of a low supporting wall.

TUBE TILE.

A full set of special ...... fire clay tube tile is to be furnished for covering the top and the bottom rows of tubes.

TILE BARS.

Two tile bars made of 1¼-inch square iron are to be furnished for ...... circulating drum. These bars are to be held in place by means of wrought iron hangers located at intervals of four feet, and securely bolted to the shell; the purpose of the bars being to support the ends of the tiling, closing in around the drum.

...... drum is to be furnished with a .... flange having an internal diameter of .... inches, and riveted to the top of the shell, a distance of .... inches between the center of the same and the front edge of the shell plate.

A ...... inch feed pipe connection is to enter the front head of ...... drum as near the bottom as possible,

extending towards the rear, and arranged to discharge directly over the opening leading to the rear water leg.

All seams around the perimeters of the water legs are to be furnished with single riveted lap joints with rivets spaced a distance of 2 inches center to center, and having a diameter, after being driven, of 13-16 inch. At the throats, where the legs are attached to the circulating drums, double riveted lap joints are used.

CIRCULATING DRUM.

..... boiler to be furnished with ..... drum.. for permitting the circulation of the water from the front water leg to the rear water leg, and also affording a steam space in the upper half. ..... drum is to have an internal diameter of ..... inches, and a length of shell of ...... feet ...... inches. The heads of ...... drum.. are to be dished to a radius equal to the diameter of the shell, and the rear head is to be furnished with a manhole of the Hercules pattern approximately 10x16 inches in size. At the forward end of .... drum is to be located a baffle plate extending towards the rear a distance of about 6 feet and located directly underneath the steam opening, so as to prevent any entrainment in the steam. A sufficient opening is to be left between the top edge of the baffle plate and the top of the shell to give an area equal to at least one and one-half times the area of the steam opening.

TRIMMINGS.

...... boiler is to be furnished with .... inch pop safety valve ...... set to blow at ...... lbs. per square inch, one ...... feed valve, one ...... check valve, ... 1¼ inch asbestos-packed blow-off cocks,

one water column fitted with 1½-inch pipe connections to boiler, three ¾-inch gauge cocks, one ¾-inch glass water gauge with brass valves and guard rods, and one ...... steam gauge with syphon.

The shell plate of ...... circulating drum is to be cut away at the points where it joins to the water legs; this opening to be reinforced by means of ...... plate steel throat stays made of ½-inch flange steel thoroughly riveted to the same.

All shell plates are to have a thickness of ...... inch, and the heads a thickness of ...... inch.

The circumferential seams are to be furnished with single riveted lap joints, and the longitudinal seams with ...... riveted ...... joints.

BUCK STAYS.

.... ( ) buck stays are to be furnished with ...... boiler... Each buck stay is to consist of two rolled steel angles, 3½ inches by 3½ inches by ⅜ inch in size, bolted together back to back at intervals of about three feet and separated by means of thimbles placed on the outsides of the bolts, a distance of 1¼ inches throughout the entire length. ...... tie rods made of ...... round iron, provided with all the necessary nuts and washers, and of sufficient length to extend entirely across the width of the setting, are to be furnished with the buck stays.

FIRE TOOLS.

...... boiler.. ..... to be furnished with a set of fire tools, consisting of a scoop, hoe, rake and slice bar. There is also to be furnished one 3½-inch tube scraper with handle.

SMOKESTACK.

...... smokestack is to be furnished with ...... boiler.. having a diameter of ...... inches, and a height of ...... feet ....

TESTING AND INSPECTION.

A hydrostatic pressure of ...... pounds per square inch is to be applied to ...... boiler before it leaves the works, and a certificate of said test, together with a policy of insurance for $...... for one year, issued by any reliable boiler insurance company, is to be furnished.

SPECIFICATIONS FOR A HORIZONTAL TUBULAR BOILER.

NUMBER, TYPE AND SIZE.

There shall be .... boiler.... of the Horizontal Tubular Type, each having a diameter of ...... inches and a length, as measured from out to out of heads, of ...... feet ...... inches.

TUBES, ARRANGEMENTS, ETC..

...... boiler is to contain .... tubes, each having an outside diameter of ...... inches and a length of ...... feet. Each tube is to be of the best lap-welded quality, standard gauge in thickness and made of .... All tubes are to be thoroughly expanded into the tube holes of the heads, and after this is done the ends are to be neatly beaded over by means of round-nosed tools, driven by pneumatic pressure. The tubes are to be arra-- ' '- vertical and horizontal

rows, with a clear space of one inch between them, vertically and horizontally, except the central vertical space, where a distance of two inches shall be allowed.

PLATES, QUALITY, THICKNESS, ETC.

All plates used in the shell of ...... boiler... are to be made of the best .... steel, having a tensile strength of not less than 60,000 pounds per square inch, and a thickness of .... The heads are to be made of the best open hearth homogeneous flange steel, of the same tensile strength as that mentioned for the shell plates and having a thickness of ....

All plates are to be plainly stamped with the name of the manufacturer, the tensile strength and the quality, said stamps to be so located as to be easily visible after the boiler .... been completed.

RIVETING.

The longitudinal seams are to be furnished with ...... riveted ...... joints, with all rivets so arranged as to come well above the fire line.

BRACING.

The boiler heads are to be braced by means of weldless steel crow-foot braces, having a diameter of ..... inches, so as to be of equal strength as the boiler shell.

DRY PIPE.

A dry pipe is to be located on the inside of ..... boiler shell and is to be connected to the ...... steam opening by means of a special tee, located in the center. This dry

pipe is to be closed at both ends and is to be furnished with a sufficient number of ½-inch diameter holes located on the upper side to give an area equal to twice that of the steam opening. Both ends are to be closed and a ¼-inch diameter drip hole is to be located on the bottom of the dry pipe near each end.

MANHOLES.

A manhole of the Hercules pattern is to be located in the front head beneath the tubes, and another ....
....

CASTINGS.

.... boiler.. to be furnished with a ...... fire front of the .... pattern. ...... boiler is to be furnished with a sufficient number of standard cast iron grate bars to cover a width of ...... inches and a length of ...... inches; one back grate bearing bar; one soot door and frame; ...... skeleton arch plates. ...... boiler.. to be furnished with ...... buck staves, provided with tie rods, nuts and washers.

TRIMMINGS.

...... boiler is to be furnished with one .... safety valve; one ...... blow-off valve; one ...... feed valve; one ...... check valve; one combination steam and water column, with ...... pipe connections to boiler; three gauge cocks; one glass water gauge, with brass valves and guard rods; and one steam gauge, with syphon.

BREECHING.

....

SMOKESTACK.

One smokestack is to be furnished for ...... boiler.. having a diameter of ...... inches and a height of ..... feet, made of ..... sheet steel, and furnished with ..... feet of ...... galvanized strand for guys.

BOILER SUPPORTS.

....

TESTING AND INSPECTION.

A hydrostatic pressure of ...... pounds per square inch is to be applied to ..... boiler before it leaves our works, and a certificate of said test, together with a policy of insurance for ...... for one year, issued by any reliable boiler insurance company, is to be furnished.

SMOKE CONSUMERS.

There should be no trouble from any objectionable amount of smoke in the proper incineration of refuse, as there can only be complete incineration with perfect combustion, and a furnace constructed so as to secure such combustion, cannot smoke.

The use of an auxiliary furnace as a smoke or a stench consumer, is therefore not only most expensive, but entirely unnecessary.

With boiler furnaces it is different, as perfect combustion is not essential, and therefore smoke can only be avoided in such classes of furnace by a good fireman.

As a rule, all mechanical smoke consumers are only a waste of time and money, for while it is possible to cut out as much as 80 per cent or 90 per cent of the smoke, the amount of steam necessary to do this is exceedingly

large, and all such steam jets are a nuisance in themselves from their most objectionable noise.

The principles upon which all these steam jets depend for their operation are the same, being as follows:

(1) By passing the steam over the fire so as to strike low on the bridge wall the hydrocarbons are not allowed to pass higher than the steam, for the reason that as soon as they come in contact with the moisture of the steam, they are precipitated back into the fire and are consumed.

(2) In forcing a jet of steam into the furnace a greater circulation of gases is produced, thereby securing greater combustion and efficiency from the fuel.

(3) In passing steam over the fire a large amount of oxygen is drawn into the furnace, both above and below it, thereby burning all hydrocarbons before they strike the boiler tubes, and consequently there is nothing to pass off as smoke.

But at times it is necessary to use such mechanical devices, and one of the best on the market is what is known as the Hydrocarbon System. In this system for smoke prevention a specially designed patented door apparatus is substituted for the ordinary fire door, so arranged that the air is heated first, and passed into the fire chamber over the fire, and by a peculiar arrangement distributed in proper proportions (suited to varying conditions of fuel used or requirements), to form an induced draft, supplying to the carbon from the coal the needed amount of free oxygen to change the conditions of the combustible gases from carbonic oxide to dioxide and mon-oxide gases.

In addition to this another element of heat is added to the coal, by superheating a small amount of steam in a heavy metal retort, and dis-associating the steam, there-

by forming hydrogen gas which is ejected into the fire chamber, in combination with the induced draft, thus forming a valued adjunct and increasing the ratio of evaporation, owing to less frequent firing and the use of slicing bars, less deposit of soot in or on tubes and shell, and less ash to remove.

Type of Corliss Engine.

Fig. 47.

CHAPTER XIV.

CLASSES OF ENGINES AND PUMPS.

ENGINES.

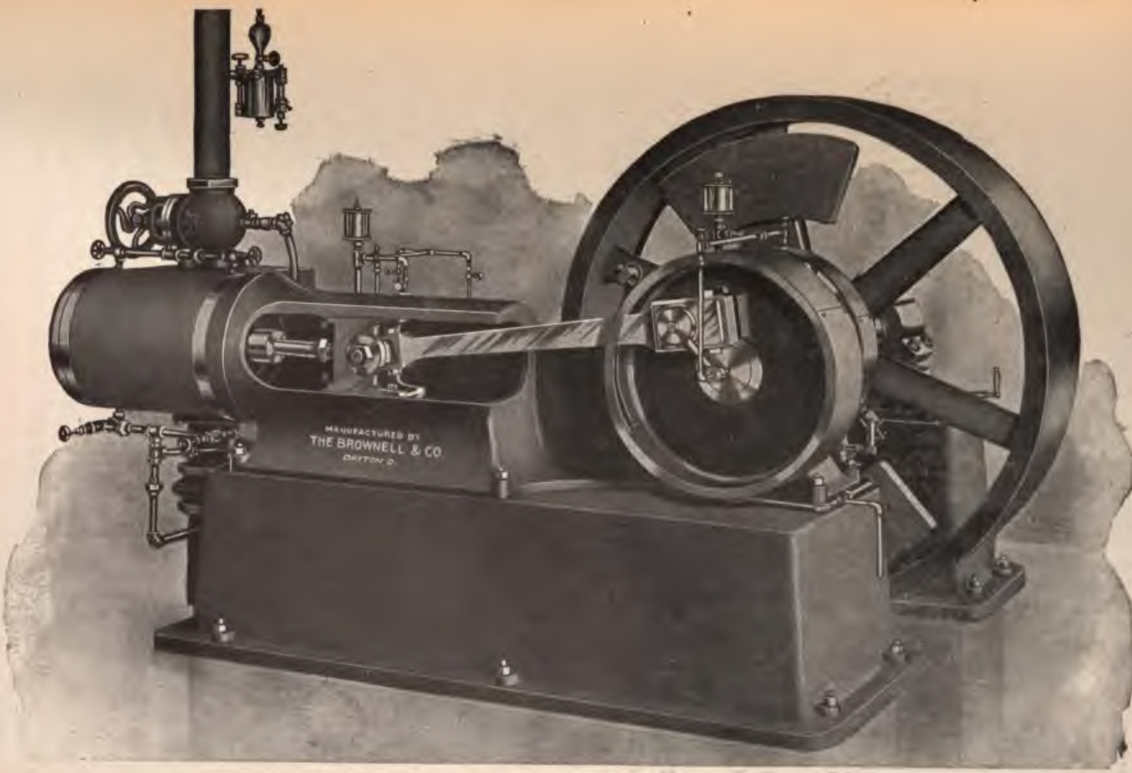
Engines are classified according to the work for which they are built, as: (1) stationary, portable, etc.; (2) from arrangement of the cylinders as, simple, compound, triple expansion, etc.; (3) according to the kind of valves to control the distribution of the steam as, plain slide valve, automatic cut-off, Corliss, etc.; (4) according to the motion of the piston, as reciprocating and rotary.

The principal subdivisions of these types are: (1) condensing, (2) noncondensing.

In most engines the steam distributing valves receive their motion from one or more eccentrics, and to have a perfect understanding of any character of engine, the first essential is to have a thorough understanding of its valve gear, by which is meant the eccentric, eccentric strap, eccentric rod, rocker, valve stem, and distributing valve. (Figs. 49 and 50.)

The simplest valve gear is that of the slide valve type, which is usually operated with only one eccentric, which is fastened to the shaft of the engine. (Fig. 48.)

The principles involved in this type of engine are the same as in the more complicated types, and its use and operation are too well known to be described in a work of this character.



Type of Slide Valve Engine. Shaft Governor.

Fig. 48.

CORLISS ENGINE.

(Fig. 47.)

This type of engine is generally used in large plants, being the most economical, owing to the close regulation of the steam supply by the automatic changing of the point in the stroke of the piston at which the steam supply is cut off.

This is accompanied by using some form of trip gear similar to the one first introduced by its inventor, Geo. Corliss.

In the Corliss gear there is a separate admission valve and a separate exhaust valve for each end of the cylinder, entirely independent of each other. The admission valves are operated by either one or more eccentrics, but they are automatically closed by dash-pots or springs, when the piston reaches a designated point of its stroke. This point will vary with the position of the governor, which position will vary with the speed of the engine, which is controlled by the load on the engine.

The exhaust valves are opened and closed by the motion of a wrist plate to which these valves are directly connected by rods or cranks. Both the admission and exhaust valves are cylindrical in shape, turning in cylindrical seats which extend across the ends of the cylinder. The wrist plate which operates the exhaust valves alone receiving its oscillating motion from the eccentric which is fastened to the shaft of the engine.

When the piston reaches the point where the steam should be shut off, the trip gear is held in such a position by the governor that it releases the admission valve, which is snapped shut by the action of the dash-pot, or spring. The exhaust valve is made to open by the in-

dependent action of the wrist plate which is operated by its eccentric.

The advantage of the Corliss valve gear is the long range of the stroke through which the cut-off can be varied, depending only on whether one or more eccentrics are used.

With one eccentric, the cut-off ranges from the beginning of the stroke to one-half, at which point the eccentric starts on its return travel. With the use of two eccentrics this range can be extended almost the entire stroke, as the exhaust valves are operated entirely independent.

The Corliss engine is not a high speed engine, owing to the time it requires for the trip gear to act.

CONDENSING AND NONCONDENSING ENGINES.

All engines are run either (1) condensing, in which the exhaust steam is condensed and used over again, or, (2) noncondensing, in which the exhaust steam is discharged into the atmosphere.

Unless this exhaust steam is used for heating or for other purposes, it is manifestly a most extravagant way to operate a plant of any size, for not only is there a waste of valuable water of condensation or heat, but it forces the engine to work against the back pressure of the atmosphere, which means more fuel necessary for steam to overcome this useless work.

For the purpose of removing this pressure on the engine by means of a partial vacuum, two principal methods of condensing the steam are employed, viz: (1) by condensers, either surface or jet, and (2) by the use of cooling towers or tables.

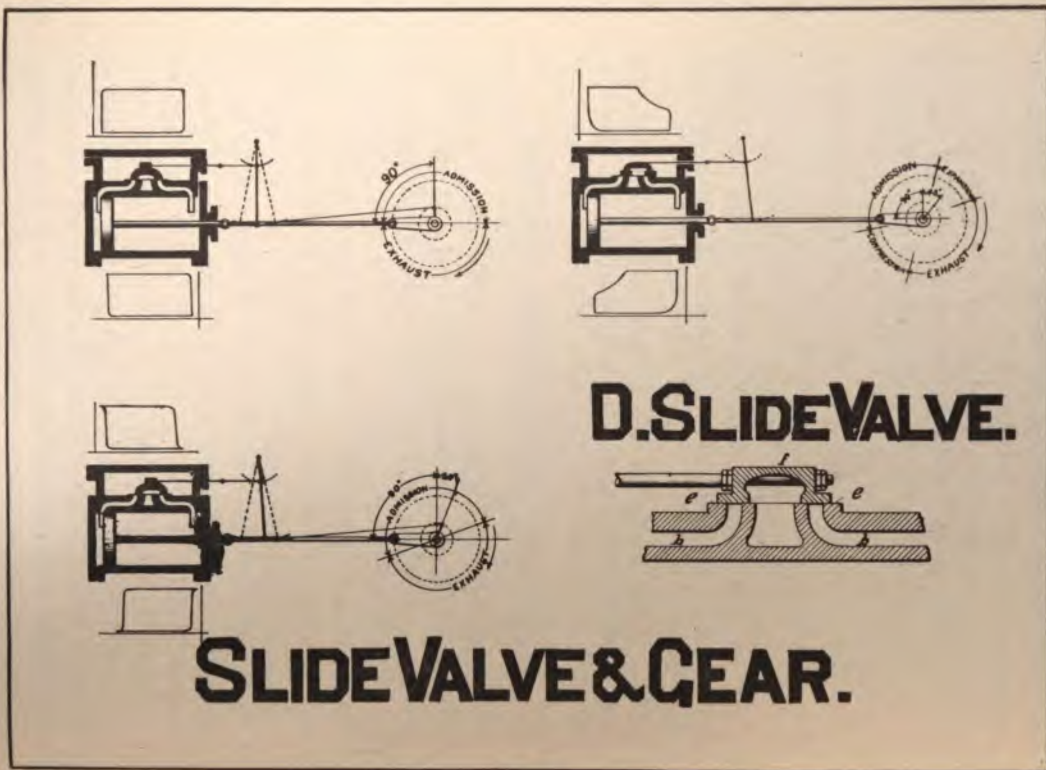

90°
ADMISSION
EXHAUST
COMPRESSION
D. SLIDE VALVE.
f
e
e
b
b
SLIDE VALVE & GEAR.

Fig. 49.

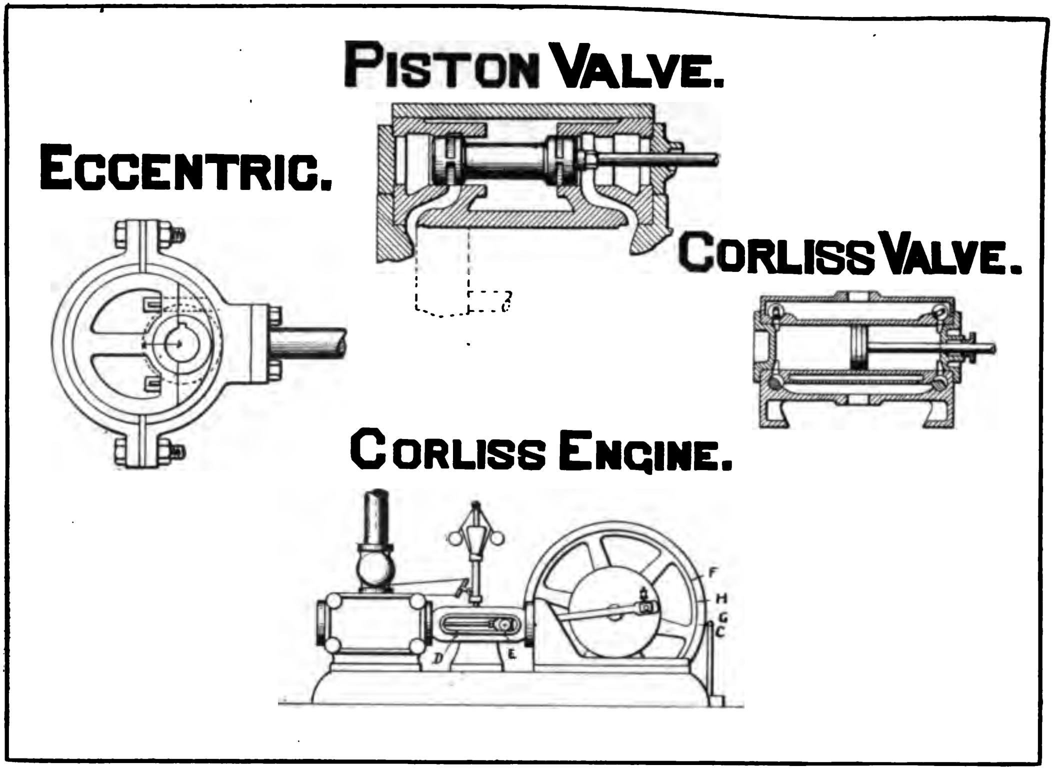

PISTON VALVE.
ECCENTRIC.
CORLISS VALVE.
CORLISS ENGINE.
F
H
G
C
D
E

Fig. 50.

A surface condenser is one in which the steam passes through pipes surrounded by cold water, or, the water flows through the pipes, which are surrounded by the steam.

In the jet condenser, the steam is condensed by coming in contact with cold water, which is introduced into the steam chamber as a spray.

Where it is impossible to get a sufficient supply of water at an economical cost, then a cooling tower or water table is used for the purpose of condensation. This is done by locating same upon the roof, and allowing the atmosphere to cool the condensation, by using a system of mats or slats over the surface of which the water flows in a thin film to a reservoir which is located at the bottom of the cooling tower.

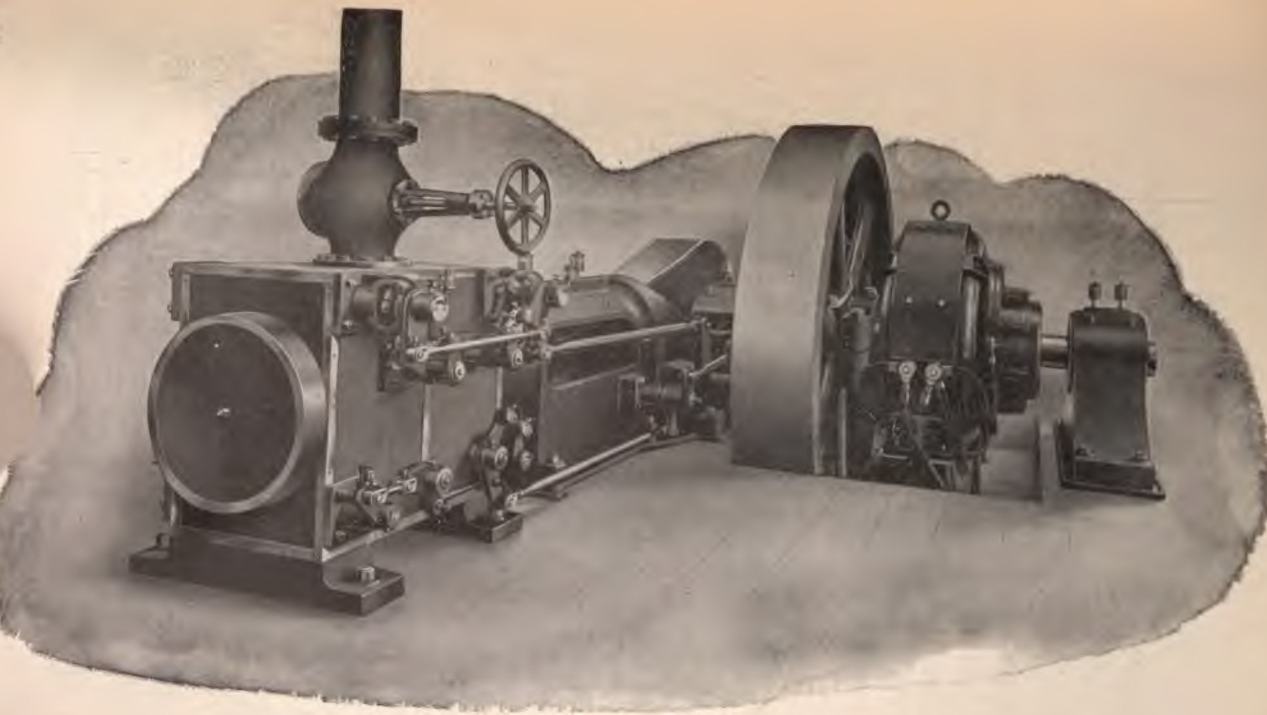
In this way the water from the condenser is used over and over again. The loss of water by evaporation when this method is used, is only from 5 per cent to 10 per cent, which loss must be supplied with fresh water from some outside source.

SPECIFICATIONS FOR CORLISS ENGINE.

Gentlemen: We propose to furnish you ....in accordance with the following specifications:

Type of Engine—Engine to be of our .... type; and to run at ...... revolutions per minute with ...... pounds steam pressure .... hand.

Cylinder Dimensions—Diameter of H. P. cylinder.... inches. Diameter of L. P. cylinder ..... inches. Length of stroke ...... inches.



Hamilton Corliss High Speed Engine.

Fig. 51.

Power—.......I. H. P. .... lbs. steam pressure ......cut-off. .... I. H. P........ lbs. steam pressure ...... cut-off. ...... I. H. P. ...... lbs. steam pressure ...... cut-off. ...... I. H. P. ...... lbs. steam pressure ...... cut-off.

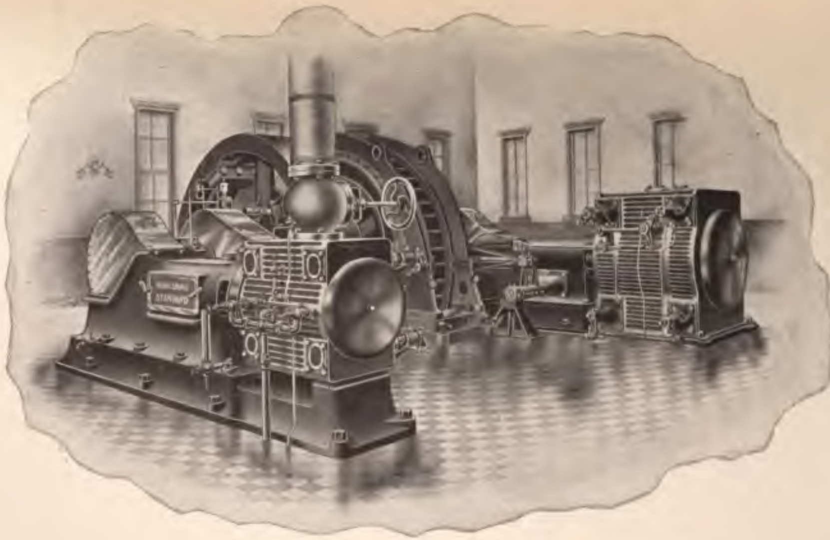
Material—The cylinders to be made of clean hard close-grained iron. Will be covered with sheet steel lagging with polished corner irons. Space between jacket and cylinder to be filled with asbestos or best quality mineral wool. Steam pipe ...... inch in diameter. Exhaust pipe ...... inches.

Frame—The frame to be used for this engine to be our .... and guaranteed to stand the severest strains without showing any form of weakness. The guides to be of the ...... type, insuring perfect alignment with the cylinder.

Wheel—...... wheel ...... ft. diameter, ... inch face, and to weigh ...... pounds. Made in ...... and accurately turned and bored. Wheel to be grooved for ...... inch ropes ...... systems of grooves.

Shaft—Shaft to be ...... in diameter at bearing..... between bearing. Bearings ...... diameter...... long. The main bearings to be provided with removable top, bottom and quarter boxes, lined with best quality babbitt metal, hammered in and accurately bored and scraped to a true bearing surface. Quarter boxes are adjustable with wedges fitted with adjusting screws, and of such design that the wedges and boxes may be removed without moving shaft. Cap to have a feel hole for examining journal without disturbing adjustment of bearing.

Crank and Crank Pin—The crank will be of our standard type, polished on the face, pressed on shaft and keyed



The Harrisburg Four-Valve Engine.

Fig. 52.

in place. The crank pin will be ...... inches diameter, ... inches long, pressed in crank and riveted over.

Valve Gear—Cylinder to be equipped with improved valve gear of the hook releasing type, which is so designed as to subject all parts to a minimum amount of strains. Steam valve hooks and levers to be fitted with reversible hardened steel catch plates.

Piston—...............

Crosshead—The crosshead is of the solid box form, having shoes adjustable with wedges, having bearings the entire length, which can be removed without disengaging connecting or piston rods. The shoes are lined with best quality antifriction metal scraped to fit guides. Piston rod will be of open hearth steel, finished and polished and secured to crosshead by a thread and jamb nut, so the clearance space in cylinder can be equalized at any time.

Connecting Rod—The connecting rod is made from a single forging with solid ends. The brasses have large wearing surfaces lined with best quality of babbitt metal, and are adjustable with wedges.

Governor—The governor will be of our standard type and will control the variations in speed to the least possible range. An automatic stop will be provided, so in case governor belt should break it would shut the engine down.

Fixtures and Fittings—The following fixtures and fittings will be furnished: Nickel-plated sight feed oilers for main journals, eccentrics and guides, stationary centrifugal sight feed oilers for crank pins; throttle valve, full set of wrenches for the parts of engine that require adjustment, automatic cylinder lubricators, foundation bolts and washers and foundation plans.

Material and Finish—Shaft and connecting rods to be of best quality hammered wrought iron, free from flaws or other imperfections, and to be nicely finished. Pistons and eccentric rods, crank and crosshead pins, also wrists of valve gear to be of best quality forged steel. Great care will be exercised in making the castings of best quality as regards strength, wearing qualities and smoothness. All castings subject to wear will be poured from special heats of charcoal iron mixture. All parts will be made to gauge and interchangeable. Workmanship and finish will be first-class in every particular. Engine to be primed, rubbed down, painted and varnished.

Guarantee—We guarantee the workmanship and material in the engine to be first-class, and we will furnish without charge a duplicate of any part that may prove defective in material or workmanship, provided an inspection proves the claim, within one year after engine is started. We guarantee the engine to run smoothly and in a proper manner, without undue heating or vibration.

Conditions of Operation (300 I. H. P. Noncondensing) —The engine is to run noncondensing at 200 revolutions per minute. Steam pressure 125 lbs. above the atmosphere. Back pressure 15 lbs. absolute. The maximum load for which engine is intended equals 400 I. H. P. The engine is to operate at highest efficiency with load equal 300 I. H. P. The average load will equal 175-200 I. H. P.

Speed Regulations—The speed regulation shall be within 1.5 per cent above or below normal.

Piston Speed—The piston speed regulation shall be not less than 560 feet per minute, nor more than 600 feet.

Clearance—The clearance shall not exceed 8 per cent.

Erection—We will furnish the time of one man ..... days to superintend the erection and start engine, his traveling expense and board to be paid by you. We consider as legitimate traveling expenses, railroad fare and transfer charges, sleeping cars (when traveling at night), meals enroute, excess baggage or other transportation charges on tools or materials. You are also to prepare the foundations in accordance with our plans, do all piping, packing, belting, mason and carpenter work, and furnish all laboring help and requirements to facilitate erection. When delays are caused to our man by material or labor not furnished by us, you agree to pay his time at $5.00 per day and expenses while so delayed; our responsibility being limited to the engine proper and the accuracy of our plans.

Price—We propose to furnish the foregoing machinery as specified for the sum of .... dollars ($...).

Terms of Payment—Payment to be made as follows: ...... when engine is ready for shipment; balance ..... days after shipment.

PUMPS.

Pumps vary greatly in design, depending on the character of work for which they are constructed.

They are now made to handle water, beer, molasses, acids, oils, melted lead, and such gases as air, ammonia and oxygen.

The different types used to cover this large field of work are defined as chain, diaphragm, jet, centrifugal, rotary and cylinder pumps.

It is only the last three types, viz.: rotary, centrifugal and cylinder pumps that are used in the field covered by this work.

ROTARY PUMPS.

The action of these pumps depend upon the force given to the water, or other liquid, by the action upon it of two tooth wheels, which are made to revolve in an enclosed chamber, each tooth of these wheels acting as a small piston, and pushing the water or liquid ahead of it. The flat faces of these wheels should be made a snug fit between them and the casing, and the edges of the teeth also a good fit against the sides of the casing. These pumps occupy but little space, and are light and inexpensive, but are of low efficiency. They are chiefly used to pump heavy liquids, or water holding in suspension large masses of soft material.

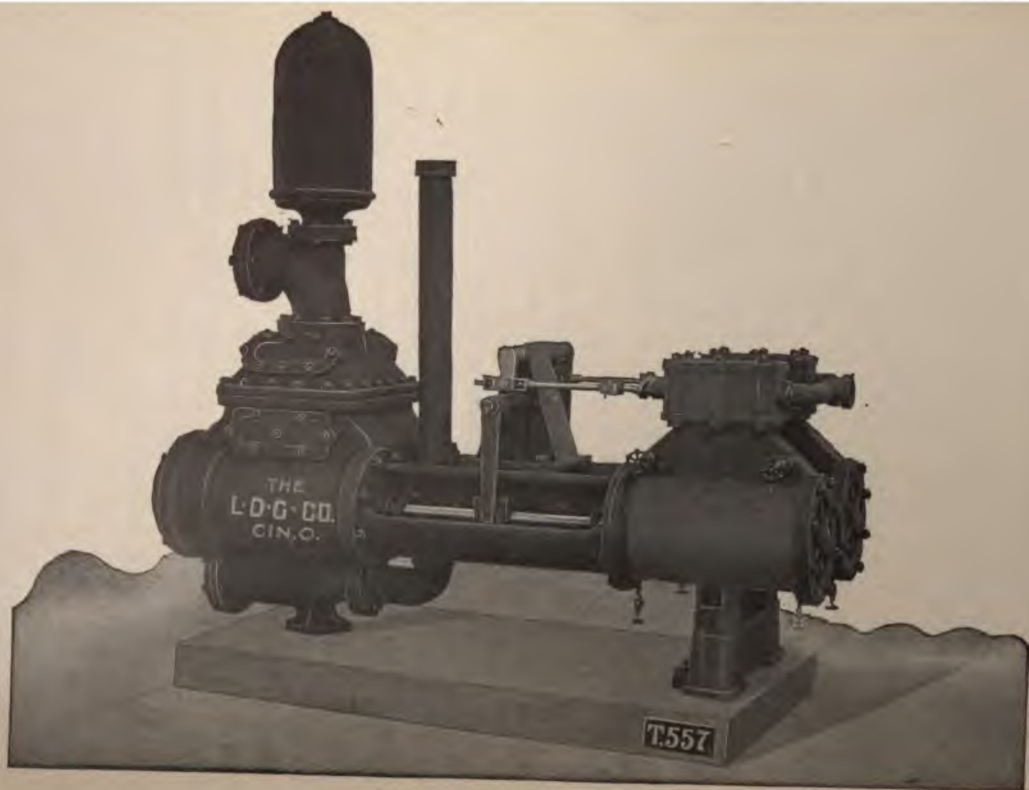
CENTRIFUGAL PUMPS.

Pumps of this type depend for their action upon the pressure produced by the centrifugal force of the water rotated rapidly by the vanes of the pump. As it is the centrifugal force upon which these pumps must rely for moving the water or other liquid, they are designated by that name.

These pumps are only efficient when working under low lifts, being limited to a lift not exceeding forty feet. They are well adapted for pumping large volumes of dirty water or sewerage, and are therefore much used for sewerage pumping and dredging.

CYLINDER PUMPS.

These are power pumps used principally for boiler feed, compressed air, or vacuum purposes.



Duplex Steam Pump.

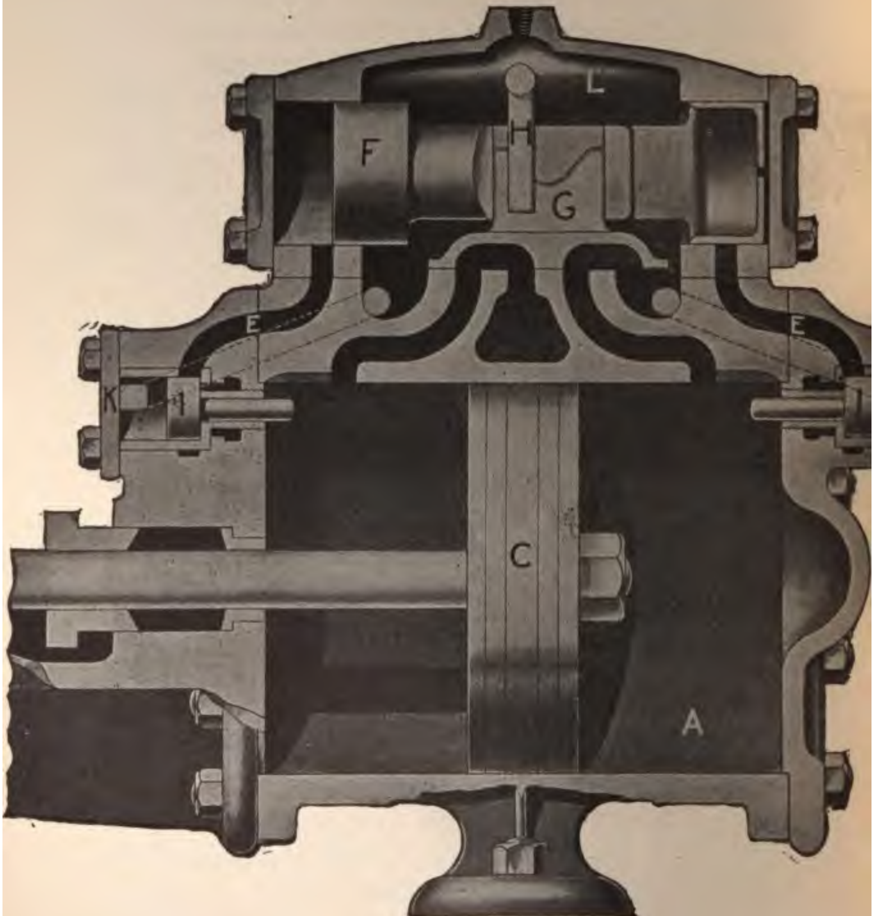
Pumps of this class consist of the combination of a steam engine forming one end of the pump, the other end being for the pumping and discharge of the water or air. The two ends are operated by a single piston rod which extends through the pump from one end to the other, thereby making their action direct, hence they are called direct acting steam pumps.

DUPLEX PUMPS.

Such pumps consist of two steam pumps, as above described, placed side by side, so that the slide valve of each cylinder gets its motion from the opposite piston rod acting upon a lever and a rocker arm.

The effect of this arrangement is to produce a steady flow of the water, or liquid, without the usual strains produced when the flow of the same is suddenly arrested, and then started again, as is the case in single direct acting pumps.

In duplex pumps the two pistons move in opposite direction, making the action of the pump continuous. The valve has neither outside nor inside lap and hence the steam cannot be used expansively. The steam valve is carried along by coming in contact with check or lock nuts placed on the valve stem. In order to arrest the steam piston when it completes its stroke, and allow the other pump to pick up the motion, thereby preventing the pump stopping altogether, a certain amount of lost motion between these check or lock nuts must be allowed. Should there not be sufficient lost motion, the pump will short stroke, if too much lost motion, then it will stop. The lost motion allowed or the auxiliary valve simply take the place of a fly-wheel, to carry the pump over its



The Cameron Pump.

Fig. 54.

centers. The rule is to allow as much as one-half of the width of the steam ports, for lost motion.

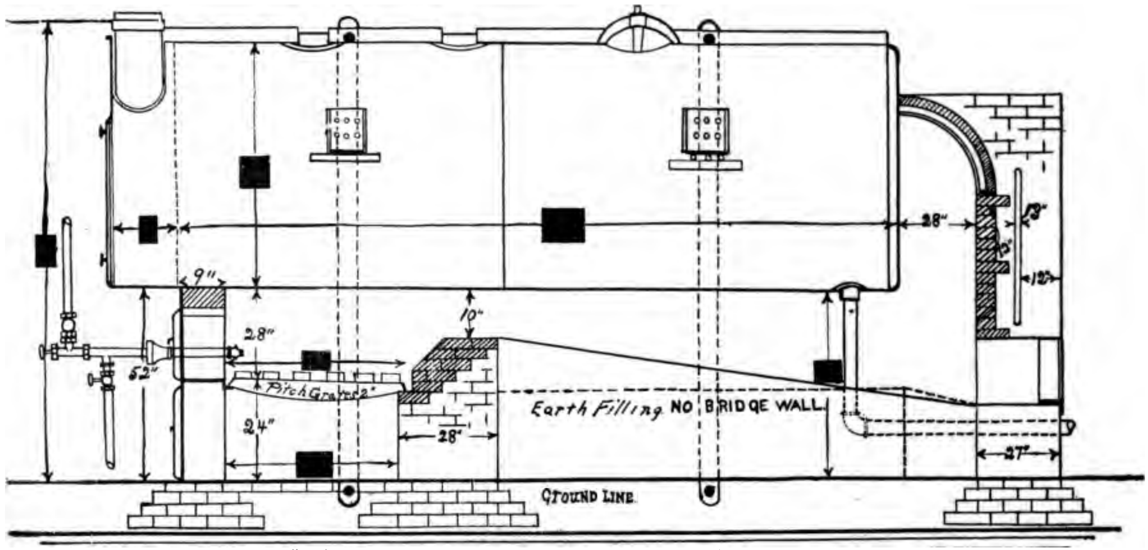
Pumps of this type are divided into two classes, viz.: (1) those having their valve gear outside, and (2) those having the valve gear on the inside, and hence having no moving parts visible, except the piston rod.

The leading make of the first class of pumps is the duplex pump, shown in Fig. 53, which pump is especially adapted for central heating plants.

Of the second class is the Cameron pump, shown in Fig. 54, and which is largely used for boiler feed purposes.

HOT WATER PUMPING.

The pumping of hot water is much more difficult than that of cold water, as the vapor from the hot water destroys the vacuum as fast as it is formed. In actual practice it is not possible to lift water whose temperature exceeds 180 degrees. Above this temperature the pump must be placed below the water supply, so that the water can flow into the pump. Such an arrangement is not necessary in central heating plants, as the hot water which is pumped through the mains rarely exceeds 170 degrees. Pumps for handling hot water must be provided with special valves of hard vulcanized rubber or be entirely of metal. Soft rubber valves are entirely unsuitable for handling hot water. The cylinder should also be brass lined throughout.



The Branch Oil Burner Installed.

(Burner Much Enlarged.)

Fig. 55.

CHAPTER XV.

GAS AND OIL INSTALLATIONS AND COMPARATIVE VALUE OF FUELS.

It can no longer be contended that the refuse of a city has no calorific value. While it is true that this value is very small, varying from one to three thousand B. T. U. per lb., it nevertheless is proportionately more valuable as a fuel than those fuels of a higher calorific value which are much more costly to obtain. While coal is the ordinary fuel used for the incineration of refuse, both gas and oil are frequently used for this purpose, and in view of the rapidly increasing use of same for fuel purposes, the following table showing their comparative value will be of interest:

Both gas and oil are ideal fuels for all character of furnace work when properly installed. Fig. 55 shows the proper installation of a Branch Oil Burner in a boiler furnace, which installation is entirely similar to its installation in an incinerating furnace. The grate bars of both firing furnaces must be covered over with fire-brick or ashes to exclude the excess of air, the same as is done when there is only one furnace. While either steam or air can be used to atomize the oil, the use of steam is preferable as it gives a much softer and more diffused heat.

The installation of gas burners differ only from that of oil burners in the requirement of a much less air or steam pressure for their operation.

Both wood and shavings can also be used as a fuel; in fact, the requirements of a successful incinerating furnace are similar in every respect to those of a boiler furnace, for a furnace which will develop the entire efficiency of a boiler, will satisfactorily incinerate any class of refuse, the requirements being in both cases, *complete combustion.*

Table of American coals, showing value for steam-making, and the evaporation per pound of coal from and at 212 deg. F.:

STATE.	Kind of Coal.	Per Cent of Ash.	In Heat, Units per Pound.	In Pounds of Water Evaporation.	Percentage of Incombustible Matter.	Heat Units Available for Steam-making.	Horse Power for 1 pound of Coal.	Evap. 100 Per Cent.
Pennsylvania,	Anthracite,	3.49	14.199	14.70	0	14.500	5.074	15.01
Pennsylvania,	Anthracite,	6.13	13.535	14.01	1	14.355	5.647	14.86
Pennsylvania,	Anthracite,	2.90	14.221	14.72	2	14.210	5.590	14.60
Pennsylvania,	Cannel,	15.02	13.143	13.60	3	14.065	5.533	14.44
Pennsylvania,	Conelsville,	6.50	13.368	13.84	4	13.920	5.436	14.40
Pennsylvania,	Semi-bituminous,	10.77	13.155	13.62	5	13.775	5.418	14.25
Pennsylvania,	Stone's Gas,	5.00	14.021	14.51	6	13.630	5.361	14.10
Pennsylvania,	Youghiogheny,	5.60	14.265	14.76	7	13.485	5.305	13.94
Pennsylvania,	Brown,	9.50	12.324	12.75	8	13.340	5.243	13.80
Kentucky,	Caking,	2.75	14.391	14.89	9	13.195	5.190	13.65
Kentucky,	Cannel,	2.00	15.198	16.76	10	13.050	5.133	13.51
Kentucky,	Cannel,	14.80	13.360	13.84	11	12.905	5.706	13.35
Kentucky,	Lignite,	7.00	9.326	9.65	12	12.760	5.019	13.20
Illinois,	Bureau Co.,	5.20	13.025	13.48	13	12.615	4.962	13.05
Illinois,	Mercer Co.,	5.60	13.123	13.58	14	12.470	4.905	12.90
Illinois,	Montauk,	5.50	12.659	13.10	15	12.325	4.848	12.75
Indiana,	Block,	2.50	13.588	14.38	16	12.180	4.791	12.60
Indiana,	Caking,	5.66	14.146	14.64	17	12.035	4.743	12.45
Indiana,	Cannel,	6.00	13.097	13.56	18	11.890	4.637	12.30
Maryland,	Cumberland,	13.98	12.226	12.65	19	11.745	4.659	12.18
Arkansas,	Lignite,	5.00	9.215	9.54	20	11.600	4.563	12.00
Colorado,	Lignite,	9.25	13.562	14.04	21	11.455	4.545	11.85
Colorado,	Lignite,	4.50	13.866	14.35	22	11.311	4.449	11.70
Texas,	Lignite,	4.50	12.962	13.41	23	11.165	4.392	11.55
Washington,	Lignite,	3.40	11.551	11.96	24	10.920	4.295	11.30

PETROLEUM.

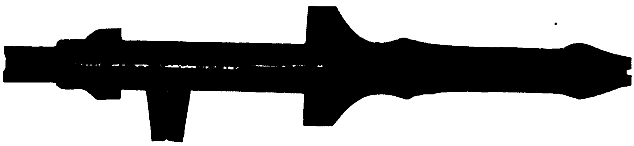
Crude oil, fuel oil, or any distillate:
Per cent of ash, .0.
Heat units per pound, .20.746.
Pounds of water evaporation, 21.47.
Per cent incombustible matter, 25.
Heat units available for steam-making, 10.920.
Horse power per pound, 4.238.
Evaporation per pound from and at 212 deg. F., 11.25.

REFUSE.

This includes increased output refuse, garbage and all character of municipal waste. Below is given the results of official tests made in twenty-two English cities of the fuel value of refuse, the evaporation being taken from and at 212 deg. F.:

Accrington, 1.39 pounds.
Beckenhowe, 1.512 pounds.
Blackburn, 1.297 pounds.
Bolton, 0.8 pounds.
Bradford, 0.882 pounds.
Bury, 1.58 pounds.
Colme, 1.00 pound.
Dorwen, 1.71 pounds.
Fleetwood, 1.191 pounds.
Grays, 1.22 pounds.
Hackney, 1.415 pounds.
Hereford, 1.65 pounds.
Lancaster, 1.63 pounds.
Liverpool, 1.173 pounds.
Nelson, 1.516 pounds.
Pembroke, 1.21 pounds.

Rochdale, 1.72 pounds.
St. Helens, 1.54 pounds.
Salisbury, 1.10 pounds.
Wakefield, 1.4 pounds.
Wendsworth, 1.20 pounds.
West Hartlepool, 1.25 pounds.



The Branch Oil Burner—Sectional View.

Fig. 56.

CHAPTER XVI.

FORMS OF FRANCHISE AND ORDINANCES.

Owing to the character of this work and the various requirements of modern business methods, some forms are here given to assist those who are engaged either in work for public corporations, or endeavoring to secure franchises or contracts from municipalities.

FORMS FOR FRANCHISES AND CITY ORDINANCES.

Chapter 907, *Section* 6, *Page* 801, *of the Revised Statutes of the United States*:

SEC. 6. That it shall not be lawful to cast, throw, empty or unload, or cause, suffer or procure to be cast, thrown, emptied or unloaded, either from or out of any ship, vessel, lighter, barge, boat or other craft, or from the shore, pier, wharf, furnace, manufacturing establishments or mills of any kind whatever, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, slag, cinders, ashes, refuse or other waste of any kind, into any part, road, roadstead, harbor, haven, navigable river or navigable water of the United States which shall tend to impede or obstruct navigation, or to deposit or place, or cause, suffer or procure to be deposited or placed, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, or other waste in any place or situation on the bank of any navigable waters where the same shall be liable to be washed into such navigable waters, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed.

AN ORDINANCE GRANTING A FRANCHISE FOR A CENTRAL HEATING SYSTEM.

An ordinance granting the right of way in and under the streets and alleys and public grounds of the city of ...., and the privilege of constructing, maintaining and operating a plant for the distribution of steam or heated water, or both, for domestic, heating or power purposes.

Be it ordained by the City Council of the city of ....

SECTION 1. That there is hereby granted to ...., of ...., their successors and assigns (who are hereafter in this ordinance called the grantees), upon the terms and conditions hereinafter set out, and for the period of fifty years from the taking effect and acceptance of this ordinance, the right of way for laying, constructing and maintaining, in and under the streets, alleys and public grounds of said city, the pipes and mains and all branches, cut-offs and manholes, necessary for the distribution to public and private consumers, of steam or heated water, or both, for domestic heating or power purposes, and the privilege of constructing, maintaining and operating in said city the necessary power plant and machinery to operate the same, and to make all necessary excavations therefor.

SEC. 2. All pipes, pipe lines and appliances constructed hereunder shall be, as far as possible, constructed, laid and maintained in the alleys of said city, and only in streets where no alley exists in the block adjacent, running in the direction the main is to be laid. During the laying of the pipes and mains, or in repairs and exten-

sions thereof, the grantees shall not unnecessarily obstruct the streets, alleys and public grounds, and shall complete each part of the work therein without unnecessary delay, and shall restore such street, alley or public ground to as good a condition as before the grantees entered thereon, and to the satisfaction of the street and alley committee of said council; and upon failure to make such repairs the city may cause the same to be done; and the grantees hereby agree to reimburse the city for the cost thereof.

SEC. 3. The rights and privileges herein granted shall be subject to such sanitary and police regulations as the city council in its judgment may deem just and proper, in the present construction of said plant or future operation thereof; and the right is hereby granted to said grantees to make all needful rules and regulations for operating and protecting said plant, tapping mains, size of service orifices and all other appliances, supplying customers, shutting off service for non-payment of rates by private consumers, and preventing the waste or wrongful use of heat.

SEC. 4. The grantees shall hold the city of .... harmless from any injury to any person, or the property of any person or corporation, which may result from the negligence of the grantees while performing the work of laying the pipes and mains, or otherwise exercising the rights and privileges herein granted; and should the city be sued therefor, the grantees shall, upon notice from said city, appear and defend or settle the same, and should judgment go against the city in such case, the city shall recover the amount, with all costs, from the grantees, and the record of such judgment against said city shall be conclusive evidence in the cause to entitle the city to recover from the grantees.

And for the purpose of indemnifying the city against any loss or damage by reason of the construction or operation of said plant, and for the purpose of indemnifying the city for any loss growing out of the exercise of any of the rights and privileges herein granted, and for the prompt restoration of all streets, sidewalks and alleys to the same condition they were in before the excavations provided for were made, the grantees shall, within thirty days from the date fixed in this ordinance for the beginning construction of the plant provided for herein, file with the city clerk, a bond in the penal sum of five thousand dollars, with good and sufficient sureties thereon, subject to the approval of the mayor of said city; and said bond shall be renewed whenever the council shall deem the sureties thereon insufficient.

SEC. 5. Said grantees are authorized and empowered to charge consumers for steam or hot water for heating purposes, at all times when the outdoor temperature is at or below 65 degrees Fahrenheit, not exceeding the following annual rates: For steam, ... per square foot of radiating surface; for hot water, ... per square foot of radiating surface; and for hot water for bath or other purposes, where the water is removed from the pipes, not exceeding one dollar and fifty cents per thousand gallons, to be measured to the consumer by a meter to be furnished by the grantees without additional charge.

The grantees shall build and maintain, free of charge to consumers, all service pipes from any main of the plant to the outside curb of the sidewalk of the street in which said main may be laid, or if the main be laid in an alley without sidewalks, then to the property line adja-

cent to said alley; all other service and inside radiation pipe to be built and maintained by the consumer.

And in consideration of the grants herein made, the grantees hereby agree to furnish the city, free of charge, all heat required for the present or any future city hall, calaboose, or hospital buildings; provided that the amount of heat to be furnished to said city free of charge for said buildings shall not exceed in value, according to the maximum rates to consumers permitted herein, the following amounts: $...... per annum during the first fifteen years of the life of this franchise, and $..... thereafter, and for any excess of heat furnished for said buildings over said amounts during said periods respectively, the city shall pay not exceeding two-thirds of the maximum rates permitted to be charged consumers herein; the city in all cases to build and maintain all service and inside radiation pipes necessary to heat said buildings as hereinbefore provided to be done by consumers.

SEC. 6. None of the rights and privileges granted herein shall vest or take effect until the filing and approval of the bond provided for herein, etc.

ORDINANCE FOR CONSTRUCTION OF BRANCH INCINERATOR.

An ordinance authorizing and directing the....to provide by........contract for the construction and erection of one Branch Garbage Incinerating Plant for the destruction by fire of garbage, dead animals and other refuse, and the utilization of all waste heat therefrom, completely equipped and installed, including building to enclose the same, and appropriating money therefor, and designating the location of the site for same.

Be it ordained by the City Council of the City of....., as follows:

SECTION 1. The .... is hereby authorized and directed to provide by contract for the construction and erection of one Branch Incinerating Plant for the destruction by fire of garbage, dead animals and other refuse, and the utilization of all waste heat therefrom, completely equipped and installed, including building to enclose same, and all necessary platforms, approaches, and appliances for cleansing carts and other receptacles, in accordance with specifications now on file in the office of...............

SEC. 2. The said incinerating plant shall have a capacity of incinerating.........tons in twenty-four hours, and developing the boiler power set out in said specifications, and said incinerator shall be of sufficient size to hold at one time not less than two-thirds of the total amount of garbage it is to destroy each day, and be capable of converting the same into a clean ash or clinker and light smoke, within the time limit as above specified.

SEC. 3. It shall be the duty of the..............to advertise for bids for the construction and erection of said incinerating plant, completely equipped and installed, of the capacity named in Sec. 2 of this ordinance, including the building to enclose same, which shall be of brick construction, with a slate or steel roof, concrete firing floors, and steel tank plate flooring directly over the incinerator, with hoppers so arranged that in operation all garbage, or dead animals may be dumped directly into said incinerator from carts or wagons.

The chimney for said plant shall be of hard burned brick laid in cement mortar lined with fire brick, and

shall not be less than............feet high. (If iron stack desired insert specifications for such stack.)

SEC. 4. The terms of said contract shall provide for a guaranteed efficiency of complete incineration and power developed from the waste heat and gases, i. e., that the successful bidder shall furnish a competent person to direct the operation of said plant without cost to the city for a period of thirty days after completion, and demonstrate the results as specified in Sec. 2 of this ordinance, and in said specifications.

SEC. 5. A bond in the penal sum of ......thousand dollars, with two or more good and sufficient sureties shall be given by the contractor, conditioned for the faithful performance of each and all the terms and requirements of this ordinance, and the contract entered into by authority hereof, and the said specifications which are made a part of same.

SEC. 6. Payments under said contract shall be made as provided in said specifications.

SEC. 7. The location of said garbage incinerating plant shall be as follows:

* * * * * * * * *

SEC. 9. There is hereby appropriated and set apart from Municipal Revenue the sum of........dollars for the construction and erection of said incinerating plant completely equipped and installed, as herein provided for.

FRANCHISE FOR GAS WORKS.

An ordinance granting............, their successors and assigns, the right to construct, maintain, extend and operate a system of works in the City of........for the purpose of generating gas with which to furnish light, heat and power to the said city and its inhabitants.

Be it ordained by the City Council of the City of.....
....

SECTION 1. The.................., their successors and assigns, be and is hereby granted a franchise for the period of .... years from and after the date of the passage and publication of this ordinance, with the full right, power and authority to construct, maintain, extend and operate a gas plant, machinery, mines, pipes and other apparatus and appliances within the corporate limits of said City of........., as they now exist, or if the corporate limits of said city are hereafter extended, then within the corporate limits as extended, for the purpose of generating and furnishing to the said city and its inhabitants, gas for light, heat and power, and for such purposes to enter under, upon and use the streets, alleys, bridges and public places of the said city and lay and maintain, therein and thereon such mains, pipes, conduits, apparatus and appliances as may be necessary and proper, subject to the terms and conditions hereinafter provided.

SEC. 2. That no mains, pipes, conduits or other apparatus and appliances hereafter laid or constructed shall be so laid or constructed so as to interfere with or injure any of the water pipes or sewer pipes laid in the streets, alleys or public places of the said City of......; and that the same shall be placed and laid under the direction of the City Council or City Engineer.

SEC. 3. The said................, their successors or assigns, may charge a maximum rate of.......... per one thousand cubic feet of gas to be measured by a gas meter and may make all needed rules and regulations for the collection of such charges and the operation of said system.

SEC. 4. Nothing in this ordinance shall be so construed as to prevent the said city from granting to other persons, companies or corporation the right of using the streets, avenues, alleys or other public places in said city for any purposes like the grantee.

SEC. 5. Said................, their successors or assigns, shall have full right and power to assign to any person or company all the rights conferred upon it by the terms of this ordinance; provided that the assigns of such rights by the acceptance of such assignment shall thereby become subject to the terms and provisions of this ordinance; and in the event of any assignment by said grantee of the rights hereby conferred upon it such assignment shall be in writing and a duly authenticated copy thereof shall be filed in the office of the........of said City of.....................

SEC. 6. The word "grantee" as used in this ordinance shall denote the................, their successors and assigns.

SEC. 7. This ordinance shall be effective and in force from and after its passage and publication as provided by law.

AN ORDINANCE TO AUTHORIZE CITY TO ENTER INTO CONTRACT FOR DISPOSAL OF GARBAGE BY BRANCH PROCESS.

An ordinance to authorize the..............of the City of................to enter into a contract for the sanitary disposal of all slop, offal, garbage and animal matter of the City of..................by the Branch process.

Be it ordained by the City Council of the City of.... ....as follows:

SECTION 1. The...........of the City of......... is hereby authorized and directed to enter into a contract for the sanitary disposal of all slops, offal, garbage and animal matter of the City of...........by the Branch process. Said contract shall be let within thirty days from the date of the approval of this ordinance and shall provide that the contractor shall commence work under said contract not less than three months from the date of said contract. And said contract shall further provide that the works of said contractors shall be located at suitable and convenient points within the city limits, to be approved by the Mayor, and that said works shall at all times be subject to the inspection of the Health Commissioner, and other city officials, as may be designated by the Mayor.

Said contract shall be made and entered into for a period of not less than .... years, and the said contractor shall enter into bond with the city of........in the sum of..........thousand dollars, conditioned with proper sureties, that said contractor shall dispose of all slop, offal, garbage and animal matter of the City of........, in a sanitary manner, and the said City of .... shall be obligated by said contract to collect and deliver, or cause to be collected and delivered, at the works of said contractor all the slop, offal, garbage and animal matter of every description within the limits of the City of...... ..... And said bond shall cover the further condition that said contractor shall at all times fully comply with all the terms and conditions of this ordinance, and that said contract and bond shall be subject to approval by the Mayor and Council.

SEC. 2. At the expiration of ten years from the date of said contract, or at any time prior to said date of expiration, the City of...........shall have the privilege of purchasing the entire plant of said contractors at a valuation to be fixed by arbitrators, one of said arbitrators to be appointed by the Mayor of the City of........... and one of said arbitrators to be appointed by said contractors, and if said two arbitrators cannot agree as to the value of said plant then they shall, within ten days after their appointment, agree on a third arbitrator whose decision shall be final and binding to all parties. A strict compliance with the terms of this section shall be the essence of said contract.

SEC. 3. The contract for the disposal of said slops, offal, garbage and animal matter shall be let at a fixed price for each year of the term of ten years, not exceeding................thousand dollars for any one year, and upon vouchers properly certified to by the................., said contractors shall be paid monthly by the City Treasurer from a fund to be appropriated and set aside for the purpose.

SEC. 4. The contractors for the disposal of the slops, offal, garbage and animal matter are prohibited from dumping or causing to be dumped any of said slops, offal, garbage and animal matter into any public or private sewer, or any sink hole, vacant lot, public or private property, street or alley of the City of................, and said contractors or any person or persons acting for them or at their instigation, or any other firm, person or corporation shall not dispose of any of said slops, offal, garbage or animal matter other than by the Branch method from and after the date said contract goes into effect, and the contract hereafter let for the collection

and removal of said substance, shall provide for the delivery of all said garbage at the above works, at times when the same are in operation.

Any person, firm or corporation convicted of a violation of this section shall be deemed guilty of a misdemeanor, and shall be punished by a fine of not less than ....dollars nor more than.............dollars for each offense.

SEC. 5. That all ordinances, or parts of ordinances in conflict with this ordinance, be and the same are hereby repealed.

SEC. 6. This ordinance shall take effect, and be in force from and after its passage and publication.

FRANCHISE FOR ELECTRIC STREET RAILWAY.

An ordinance granting to the................, its successors and assigns, the right to construct, maintain, extend and operate an electric street railway in the City of ...., and for that purpose to occupy and use certain streets and alleys in the said city.

Be it ordained by the City Council of the City of.... ....

SECTION 1. That the............., its successors and assigns, be and they are hereby granted a franchise and right of way for a period of .... years from and after the date of the passage and publication of this ordinance to maintain, construct and operate a single or double-track electric street railway of standard gauge with all necessary turn-outs, sidings, switches, wires and poles upon and along the following streets, alleys, avenues and boulevards in the City of...............to their present and future corporate limits, to-wit:

SEC. 2. Said............................, it successors and assigns, are hereby granted the right to use upon the whole or any portion of its tracks, as the same are now or may hereafter be constructed, electricity as a motive power supplied to the cars by means of a single overhead trolley wire; the electric circuit being completed by the rails of the road, and for this purpose the said..................., its successors and assigns, are hereby expressly authorized and empowered to erect and maintain in and along any and all public streets, highways, avenues, alleys and boulevards upon which the tracks of said company are now laid or which may hereafter be constructed, such posts, brackets, wires and fixtures as may be required to support and maintain the overhead trolley wire. For such support and maintenance either horizontal cross wires extending across the street or bracket arms projecting over the track or by poles in the center of the street between the tracks with bracket arms thereon projecting over the tracks as said company may deem more suitable may be employed. All such posts, brackets, wires and fixtures shall be maintained by said company at all times in good order and condition and in such manner as not unreasonably to impede public travel. Excepting when it is deemed advisable to place the poles for holding the wires in the center of the street, the poles shall be erected on the sidewalk close to the curbing and said poles shall not be less than 100 feet apart.

SEC. 3. The said street railway, with all cars thereon and all appurtenances belonging to the said Company, shall be kept in good order and repair, and shall be operated at all reasonable hours for the use of the public.

SEC. 4. The said Company shall have the right to carry mail, express and baggage.

SEC. 5. The said Company shall at all times have the right to charge and collect a fare not to exceed five cents from any passenger riding on said railway for one continuous ride from any point on the line to any other point within the corporate limits in the City of ...., providing that pupils in actual transit to and from school shall only be required to pay one-half fare.

SEC. 6. The City shall have the power and reserves the right to regulate by ordinance the rate of speed of the cars to be run by such railway; also to make any regulation the City Council may deem necessary for the safety of persons traveling on said railway.

SEC. 7. Said....................., its successors and assigns, shall have full right and power to assign to any person or company all the rights conferred upon it by the terms of this ordinance, providing that the assignee of such rights, by the acceptance of such assignment, shall thereby become subject to the terms and provisions of this ordinance, and in the event of any assignment by the ...., its successors or assigns, of the rights hereby conferred upon it, such assignment shall be in writing, and the duly authenticated copy thereof shall be filed in the office of the ....

SEC. 8. This ordinance shall be accepted in writing by the .... Company within four months after the approval and passage hereof.

SEC. 9. This ordinance shall take effect and be in full force from and after its passage and publication.

SEC. 10. That all ordinances or parts of ordinances in conflict with this ordinance be, and the same are hereby repealed.

FORM OF ORDINANCE GRANTING AN ELECTRIC LIGHTING CONTRACT AND FRANCHISE.

An ordinance authorizing the Board of Public Affairs of the City of .... to enter into a contract with ...., their successors and assigns, for the furnishing of electric lights to the city, and for other purposes.

Be it ordained by the City Council of the City of ....

SECTION 1. That the Board of Public Affairs of the City of .... be and it is hereby directed and authorized to enter into a contract with ...., their successors and assigns, for the furnishing of electric street lights to the City of ...., and for other purposes, for the period of .... years, upon the said ...., their successors and assigns entering into substantially the following agreement, to-wit:

This agreement, made and entered into this ..... day of ...., 19..., by and between............ ...., their successors and assigns, party of the first part, and the City of ...., in the State of ...., party of the second part, witnesseth:

That for and in consideration of the reduced price to be paid for each arc light, now and hereafter installed, and the installing of a modern and up-to-date plant, and electric lamps, and the giving of an all-night service, and the furnishing, without cost to the city, all electric lights required for the lighting of the Mayor's office, the City

Clerk's office, the reception room and council chamber, and for and in consideration of the sums hereinafter set out to be paid by the City of .... to the said ...., their successors and assigns, and of the mutual covenants, agreements and stipulations hereinafter set forth, the parties hereto have contracted and agreed, and do, by these presents, contract and agree with each other as follows:

FIRST.

The party of the first part promises and agrees to furnish, erect, maintain and keep lighted .... arc lights in said City of ...., for street lighting purposes, of the kind and quality hereinafter mentioned, and supply all the lamps, materials, machinery, attachments, appliances, fixtures, current, carbons, attendance and all things necessary for operating and maintaining said lights for a period commencing on the ..... day of .... 19..., and ending on the ..... day of ...., 19....

SECOND.

All arc lamps to be furnished under this contract shall be what is known as the alternating current enclosed arc lamp, having a nominal rating of 2,000 eandle-power, with an electrical energy of not less than 521 apparent watts, 6.6 amperes and from 75 to 80 volts. The lamps are to be provided with opal inner globes and clear outside globes, or both inner and outside globes to be of clear glass, as the party of the first part may elect at the time the said lamps are installed. Said lights are to burn with a steady light and to be operated and burn all night upon an every-night schedule. The lights shall begin to burn

every night one-half hour after sunset, and to burn one-half hour before sunrise throughout the year during this contract. The party of the first part agrees to furnish said party of the second part such other and additional lights, of like kind and quality, at the same rate and prices mentioned hereinafter, as the party of the second part may need and desire.

THIRD.

Said lamps shall be maintained and located where the present street arc lights are now located, and said lamps shall not be discontinued until the expiration of this contract; that any one or all of them may be moved or re-located to such places as the City Council may designate, provided always that same are located within the city limits of the City of .... No lamps shall be relocated and placed so as to require an extension of the circuits of the said ...., of more than six hundred feet to reach it, and the cost of removal of such lamp or lamps to the new location shall be paid by the City of ....

FOURTH.

In consideration of the undertakings and agreements as herein set forth, to be performed by the party of the first part, the party of the second part agrees to take from the said party of the first part two hundred arc lights, and to pay to the party of the first part as follows: The sum of $.... per lamp per year for each and every lamp installed, payable in twelve monthly installments on the 15th day of the next succeeding month in which said lights are furnished.

FIFTH.

It is further agreed that, in case of any accident or temporary stoppage of the burning of said lights, not involving the failure of the whole system of said lights, a deduction of two cents per hour, where it exceeds one-half hour, for the time each of said lights shall fail to burn, it being understood and agreed that the city shall notify the light company of the failure of any of its lamps to burn, and the penalty shall accrue from one-half hour after such notification. But this shall not apply where the causes that occasion the said failures of said lights to burn are unavoidable accidents to machinery, lights or appliances whereby the same are disabled or prevented from burning, on account of riots, strikes, fires and other causes as are known by the term, "acts of God," but in all such last-mentioned cases said lights shall be placed in repair and operated without unnecessary delay, and during the time the lights are out from any of the causes herein last specified there shall be no deductions made or penalties inflicted upon the party of the first part by reason thereof, except that the City of .... shall deduct from the total amount which the city would have to pay the party of the first part for such light or lights the pro rata amount for the time during which said lights are out, owing and arising from any of the causes herein last specified.

SIXTH.

It is understood and agreed that the said parties of the first part shall furnish said lights within six months from the date of this contract, but if the party of the first part is prevented from commencing the installation and erec-

tion of the lamps and machinery on the dates aforesaid by an unavoidable act not within its power to prevent, or by riots, strikes, fires, and any other such causes as are known by the term "acts of God," then the time for commencing said work, or the completion thereof and furnishing light with the new lamps, shall be extended for the time the party of the first part is delayed in commencing such installation and completing the same.

SEVENTH.

It is further agreed, that the party of the first part shall forever keep and save harmless the party of the second part from any and all damages, judgments, cost and expenses of same, including attorney's fees, which it may suffer or which may be recovered against the party of the second part, by reason of the carrying out of the performance of this contract by the party of the first part.

EIGHTH.

It is understood and agreed, that this contract shall inure to the use and benefit of the successors and assigns of the party of the first part.

NINTH.

In testimony whereof, the parties hereto have set their hands and seals, acting by and through their officers and agents, duly authorized, on the day and year first above written.

Attest: ....

....

City of ....

Attest: ....

By............................,

Members of Board of Public Affairs.

SEC. 2. That all ordinances or parts of ordinances in conflict with this ordinance be and the same are hereby repealed.

SEC. 3. This ordinance shall take effect and be in force from and after its passage and publication.

FORM OF ORDINANCE GRANTING A FRANCHISE FOR ELECTRIC LIGHTING, HEATING, POWER AND OTHER PURPOSES.

An ordinance to grant a franchise to .... and ...., their successors and assigns, for electric lighting, heating, power and other purposes.

Be it ordained by the City Council of the City of.... ...., State of ....

SECTION 1. That .... and ...., their successors and assigns, be and are hereby granted permission and a franchise for the erection, maintenance and placing of poles, wires and cables, laying of pipes, conduits and the necessary connections and appliances in, along, upon and over all the streets, avenues, alleys, their present and future corporate limits, bridges and other public places, in the City of ...., State of ...., for the purpose of transmitting and furnishing electricity for light, heat and power, or either of these, for public, commercial or domestic purposes and uses, together with the right at any time to enter upon and use said streets, avenues, alleys, their present and future corporate limits, bridges and other public places, for the purpose of making the necessary excavations and the placing, moving, replacing and maintaining their poles, wires, pipes, con-

duits, cables, appliances, and making the necessary connections with private property, for a period of ...... years from the passage and approval of this ordinance.

SEC. 2. That the said .... and ...., their successors and assigns, shall be permitted to charge for commercial lighting at a rate not exceeding .... cents per kilowatt hour, meas-used by meter.

The rate to be charged for power service shall not exceed .... cents per kilowatt hour, measured by meter, but the said .... and ...., their successors and assigns shall have the right to charge such flat rates for power service as may be agreed upon by the said .... and ...., their successors and assigns, and the consumer.

SEC. 3. That all sections of ordinances heretofore passed, and all ordinances or parts thereof inconsistent or in conflict herewith, be and the same are hereby repealed.

SEC. 4. That this ordinance shall be in full force and effect from and after its passage and publication.

FORM OF AN ORDINANCE FOR A CONTRACT FOR THE COLLECTION, REMOVAL AND DISPOSAL OF GARBAGE AND FIXING THE AMOUNT TO BE PAID BY THE CITY.

An ordinance authorizing the Board of Public Affairs of the City of .... to enter into a contract with .... and ...., their successors and

assigns, for the collection, removal and disposal of all slop, offal, garbage and animal matter, and fixing a maximum amount to be paid by the city for same.

Be it ordained by the City Council of the City of....
....

SECTION 1. That the Board of Public Affairs of the City of .... be and it is hereby directed and authorized to enter into a contract with .... and ...., their successors and assigns, for the collection, removal and disposal of all slop, offal, garbage and animal matter for a period of .... years, upon the said .... and ...., their successors and assigns, entering into substantially the following agreement, to-wit:

This agreement made and entered into this ..... day of ...., 19.., by and between.................. and ...., their successors and assigns, party of the first part, and the City of ...., in the State of ...., party of the second part, witnesseth:

That for and in consideration of the sanitary collection, removal and disposal of all slop, offal, garbage and animal matter, and the providing of a Branch garbage incinerator, and all necessary modern equipments for the sanitary collection and removal of all slop, offal, garbage and animal matter, and for and in consideration of the sums hereinafter set out to be paid by the City of .... to the said .... and ...., their successors and assigns, and of the mutual covenants, agreements and stipulations hereinafter set forth, the parties hereto have contracted and do by these presents contract and agree with each other as follows:

FIRST.

The party of the first part promises and agrees to furnish, erect, maintain and provide a Branch garbage incinerator and all necessary carts, horses, mules and washing and disinfecting apparatus for the complete sanitary collection, removal and disposal of all slop, offal, garbage and animal matter for a term of .... years, without cost to the party of the second part during said term, other than hereinafter provided, and in consideration of said agreement as above set forth to be performed by the party of the first part, the party of the second part agrees to pay the said party of the first part a sum not to exceed .... dollars for any one year of said term, said sum to be paid the party of the first part in twelve monthly installments by the said party of the second part on the 15th day of the next succeeding month in which said work was done.

SEC. 2. The word garbage, wherever used herein, shall be taken to mean all organic household waste, offal, animal and vegetable matter, such as has been prepared or intended to be used as food, or shall have arisen in the preparation of food, and in addition shall be construed to mean other organic industrial refuse, such as paper, cans, bottles, discarded tinware and iron, and other similar material. The contract shall also be construed to mean that the said parties shall collect, remove and dispose of all garbage from commission houses, wholesale and retail groceries, public markets, hotels, sanatoriums, hospitals, fish stores, restaurants, eating houses and apartment houses.

SEC. 3. Garbage shall be collected at all places in the city from May 1st to November 1st, during each year of the existence of this contract, three times a week; from

November 1st to May 1st, during each year of the existence of this contract, twice each week; provided, however, that collections from commission houses, hotels, hospitals, fish stores, restaurants and eating houses shall be made each day, and from public markets each market day, immediately after market hours.

For the purpose of these ordinances, an apartment house shall be understood to mean a building designed for occupancy for, or occupied by, three (3) or more families. It is further understood that collection of garbage shall not be obligatory on the said parties unless the owner shall provide and maintain garbage receptacles, one for organic garbage, and another for inorganic garbage, which receptacles shall be water-tight and air-tight, easy of access to the collector, and easy to empty, and which shall be at all times kept free from all offense to sight and smell, and from unsanitary conditions.

SEC. 4. The said parties, in the collection and removal of the garbage under this ordinance, shall, for said purpose, provide themselves with water-tight vessels, tanks or boxes, mounted on two or four wheels, which shall, when containing garbage or matter giving off noxious odors, be securely and tightly covered on top in a manner to be approved by the chief sanitary officer, so as to prevent the contents or any odor escaping therefrom, and when unloaded, after the delivery of each load to the city incinerating plant, each vessel, wagon or tank shall be thoroughly washed with hot water and disinfected by the Branch Disinfector to the satisfaction of the chief sanitary officer, and the vehicles drawing each vessel, box or tank shall be at all times so loaded and driven that none of the material shall fall upon the ground, run out or spill therefrom.

All vehicles drawing or carrying such vessels, tanks or boxes shall have on both sides thereof a sign with the words "City Garbage Cart" or, "City Garbage Wagon" painted thereon, together with the number of the vehicle, to be at all times plain and unobscured, in black letters not less than four inches in height, on white background; the number of the wagon to be registered in the office of the City Clerk.

SEC. 5. The said parties, before beginning collection under this ordinance, shall divide the city into districts, and shall deliver to the chief sanitary officer a list of the boundaries of each district and the day of the week on which they plan to make collections. The chief sanitary officer may, within thirty (30) days after the beginning of such collections according to such districts, make such charges, alterations and additions thereto as may, in the judgment of said officer, be necessary to insure the efficiency and thoroughness of collections. Thereafter, on November 1st and May 1st in each year of this contract, such contractor shall revise such districts and deliver such revised list to the chief sanitary officer, who may, for thirty (30) days, make such changes, alterations and additions to such districts as, in the judgment of said officer, may be necessary to insure the efficiency and thoroughness of such collections. Nothing in this provision shall be construed to mean that the said parties shall not at all times furnish a sufficient equipment to collect and remove all garbage and dead animals as herein provided for.

The said parties shall not be permitted to depart from the time fixed for collection, except by obtaining the written consent of the chief sanitary officer, the object being that all collections from houses in each district shall be

made on certain days, and as nearly at the same hour of the day as possible.

SEC. 6. The said parties shall furnish each householder, on May 6th and November 6th of each year of this contract, with a printed list of the days on which they will make collections, stating in such list the time of day, as nearly as possible, when such collections will be made. The printed list shall be on cardboard not less than eight inches by ten inches in dimensions, and shall contain such extracts of the city ordinance governing the responsibility of the producer of garbage, the responsibility of the collector for removal, etc., and such recommendations and rules as the Mayor and chief sanitary officer may desire to place on said card.

SEC. 7. It will be the duty of every resident, householder, tenant, hotel keeper, boarding house keeper, retail dealer, and all parties of persons occupying dwellings within the City of .... to provide, or cause to be provided, portable vessels, tanks or receptacles for holding garbage, said vessels, tanks or receptacles to be perfectly water-tight, and so kept, with a handle or handles on the outside, and provided with a tightly fitting cover, which cover shall not be removed except when absolutely necessary, or such other design of vessel, tank or receptacle can be used as shall be approved by the chief sanitary officer. Said vessels, tanks or receptacles shall be kept or placed in the rear of the house, or in the basement areas or passageways most accessible to be collected, and never upon the street, alleys, sidewalk or other public place, and shall be of a capacity of not less than one bushel, or five gallons, and as much larger as shall be deemed necessary. All such vessels, tanks or receptacles shall be accessible to the said parties

when called for, and if removed by them shall be returned by them to said place or places without unnecessary delay, and no person, except for such purposes authorized, shall in any manner interfere with said vessels, tanks or receptacles or contents thereof. In case of dispute, the chief sanitary officer shall decide as to the location to be selected for the placing of vessels, tanks or receptacles by the owner or tenant.

Should any of the above persons or parties fail to provide such described vessels, tanks or receptacles within five (5) days after receiving written notice from said parties, then the said parties are authorized to supply same, and charge a price not exceeding the regular price charged others for same.

SEC. 8. The said parties will be required to furnish to the chief sanitary officer immediate notice of the failure of any householder to have garbage ready for collection on the day set for such collection, or to provide the required receptacle for same, or make any payment due said parties.

SEC. 9. Upon complant or complaints having been made of a failure on the part of the said parties to properly collect and remove all garbage, it will be the duty of the chief sanitary officer to investigate such complaint, or complaints, and if, in his judgment, such failure to collect was the fault of said parties, he shall report such violation or violations of the ordinance to the Mayor.

SEC. 10. It shall be the duty of the chief sanitary officer to investigate all complaints made of failure on the part of the householders, tenants, hotel keepers, boarding house keepers and all parties or persons occupying dwellings within the City of ...., commission houses, wholesale and retail dealers, sanatoriums hospitals, fish stores, restaurants, eating houses and own-

ers of apartment houses to comply with the provisions of the ordinances requiring the placing of vessels, tanks or receptacles for emptying by the said parties, and to prosecute offenders under the provisions of this ordinance; or, he failing to do so, the said parties themselves can at once proceed to prosecute all violaters under this ordinance.

SEC. 11. The said parties shall provide themselves with an office, conveniently located, and furnished with a telephone. A clerk shall be regularly employed to answer all complaints and to promptly dispose of the same.

SEC. 12. Said parties shall file with the City Clerk, within thirty days from the date of the approval of this ordinance, their acceptance of its provisions, and shall at the time enter into bond with the City of ...., the sum of ten thousand dollars, with sufficient security, to be approved by the Mayor or City Council, conditioned that the said parties, or their successors, shall faithfully comply with all the provisions of this ordinance.

SEC. 13. The said parties shall pay any judgment which may be taken against said city, either alone or jointly with said parties, on account of any injury or damage to persons or property by reason of the carrying out of this ordinance, caused by the fault of said parties; provided, that if the city is sued alone for such injury or damages, due notice to the said parties to appear and defend said action shall be given.

SEC. 14. The said parties shall give to the residents of said city and county preference in the employment of all labor necessary in performing the contract, and, failing to do so, forfeit to said city the sum of five dollars for each failure to observe this stipulation.

SEC. 15. The said parties shall be required to haul, so far as possible, all garbage collected, through the alleys in the city, not making use of the prominent business or residence streets. In all cases of dispute regarding the using of an alley or street as an avenue for the hauling of garbage, or the place in any street or alley at which the garbage wagon is stopped while garbage is being collected from the neighborhood, the chief sanitary officer shall decide which route to haul upon and at which point the wagon shall be stopped to make collections. Said officer shall notify the said parties in writing of his decision, and said officer shall investigate and report to the Mayor each case wherein the said parties, after the above due notice in writing, repeat the offense; and said parties shall thereupon be liable for a fine of not less than one dollar or more than five dollars for each and every offense.

SEC. 16. Whenever there shall be annexed to the City of .... any additional territory, the Mayor or Council may order and direct the said parties to begin and continue collections and removal of garbage within such annexed territory, according to the terms and conditions of the ordinance above provided.

SEC. 17. The said parties shall deliver all slops, offal, garbage and animal matter collected as provided in this ordinance, to the city garbage incinerator works, or some other place within the city limits as may be designated by the Mayor and Council.

SEC. 18. The said parties shall be required to observe all city ordinances in relation to obstructing streets, keeping open passageways and protecting the same where exposed, maintaining signals, and generally to obey all laws

and ordinances; and said parties shall agree to indemnify and save harmless the City of .... from all suits and actions of every kind and description brought againts the city for or on account of any injury or damage received or sustained by any party or parties or by or from the said parties, their servants or agents, in the carrying out of this ordinance.

SEC. 19. The said parties shall agree to complete all equipments, vehicles and other equipments contemplated in this ordinance, and begin the collection and removal of all garbage as prescribed, within three months after passage and publication of this ordinance.

SEC. 20. Should the said parties not be incorporated at the time of the approval of this ordinance, they may thereafter incorporate under the laws of .... for the purposes herein contemplated.

SEC. 21. Any person, firm or corporation convicted of a violation of this ordinance shall be deemed guilty of a misdemeanor, and shall be punished by a fine of not less than five dollars nor more than one hundred dollars for each offense.

SEC. 22. This ordinance shall be and remain in force and effect for a period of .... years from and after its passage and publication.

In testimony whereof, the parties hereto have set their hands and seals, acting by and through their officers and agents, duly authorized, on the day and year first above written.

Attest: ....

....

City of ....

Attest: ....

By..........................,

Members of Board of Public Affairs.

SEC. 23. That all ordinances or parts of ordinances in conflict with this ordinance be and the same are hereby repealed.

SEC. 24. This ordinance shall take effect and be in force from and after its passage and publication.